THE

GEOLOGICAL MAGAZINE

OR

Monthly Journal of Geology.

WITH WHICH IS INCORPORATED

THE GEOLOGIST.

NOS. DXCV TO DCVI.

EDITED BY

HENRY WOODWARD, LL.D., F.R.S., F.G.S., F.R.M.S.

LATE OF THE BRITISH MUSEUM OF NATURAL HISTORY; PRESIDENT OF THE PALÆONTOGRAPHICAL SOCIETY; ETC.

ASSISTED BY

PROFESSOR J. W. GREGORY, D.Sc., F.R.S., F.G.S.
DR. GEORGE J. HINDE, F.R.S., F.G.S.
SIR THOS. H. HOLLAND, K.C.I.E., A.R.C.S., F.R.S.
JOHN EDWARD MARR, M.A., Sc.D. (Camb.), F.R.S., F.G.S.
J. J. H. TEALL, M.A., Sc.D. (Camb.), LL.D., F.R.S., F.G.S.
PROFESSOR W. W. WATTS, Sc.D., LL.D., M.Sc., F.R.S., F.G.S.
DR. ARTHUR SMITH WOODWARD, LL.D. (Glasgow), F.R.S., F.L.S., PRES. G. SOC.

NEW SERIES. DECADE VI. VOL. I.

JANUARY—DECEMBER, 1914.

LONDON:
DULAU & CO., LTD., 37 SOHO SQUARE, W.
1914.

STEPHEN AUSTIN AND SONS, LTD.
PRINTERS, HERTFORD.

192421
FEB 24 1915
Geology
MC
G21
M27
51

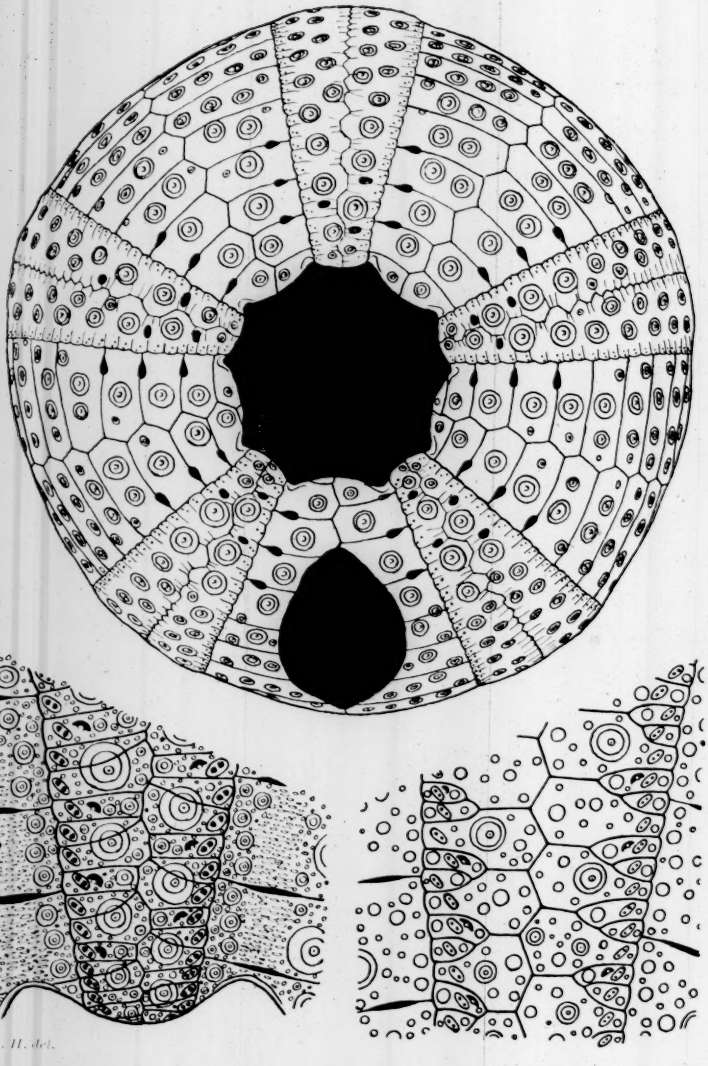
LIST OF PLATES.

PLATE		FACING PAGE
I.	Structures in the Holectypoida	1
II.	The genus *Herpetopora*	8
III.	Coal-measures, Robin Hood Quarries	49
	Portrait of Horace B. Woodward	97
IV.	Chalk Polyzoa	99
V.	Map of Kalgoorlie	107
VI.	Rock-sections, Kalgoorlie	148
VII.	Rock-sections, Kalgoorlie	152
VIII.	"*Batrachioides* the Antiquor"	158
IX.	"*Batrachioides* the Antiquor"	160
X.	*Edrioaster bigsbyi*	115
XI.	*Edrioaster bigsbyi*	118
XII.	*Edrioaster levis*	124
XIII.	*Edrioaster bigsbyi*	168
XIV.	*Edrioaster bigsbyi*	171
XV.	*Steganoblastus*	193
XVI.	Gravel-pit and Wind-worn Stones near Ramsdale	209
XVII.	Microphotographs from the Great Whin Sill	248
XVIII.	Foraminifera, Speeton Clay	264
XIX.	Foraminifera, Speeton Clay	296
XX.	*Ortonella furcata*	266
XXI.	Rock-building Organisms	268
XXII.	Sgùrr of Eigg	305
XXIII.	Malayan Clays	309
XXIV.	Malayan Clays	310
XXV.	Cave and Fissure Deposits, Mallorca and Menorca	337
XXVI.	Chalk Polyzoa	346
XXVII.	Femur of *Papposaurus*	348
XXVIII.	Glabella of *Trinucleus*.	352
XXIX.	Glabella of *Trinucleus*.	358
XXX.	Plant Cuticles, British Coal-measures	385
XXXI.	Plant Cuticles, British Coal-measures	388
XXXII.	*Griffithides Shunnerensis*, King, sp.n.	394
XXXIII.	*Typhacites Kitsoni*, Stopes	433
XXXIV.	Cretaceous Cheilostome Polyzoa	443
XXXV.	Chalk Polyzoa	481
XXXVI.	*Stenurothrips succineus*, Bagnall, n.sp.	485
XXXVII.	East Peak, Ribawe Mountains, Mozambique	529
XXXVIII.	*Arthropleura Moyseyi*, Calman, sp. nov.	541

LIST OF ILLUSTRATIONS IN THE TEXT.

PAGE

Diagram illustrating 'Cleat' in coal-seams 52
Figure showing probable ice-margin in British Isles and North Sea . . 70
Fibrous ice upon wet clayey soil 96
Humerus of *Testudo gymnesicus* 103
Femora of *Testudo gymnesicus* 106
Edrioaster bigsbyi 118
Cover-plates of *Edrioaster levis* 164
Edrioaster bigsbyi 165
Shore-lines of Ferrar Glacier and branches after submergence . . 190
Steganoblastus ottawaensis 195, 198, 200, 201
Geological sketch-map of South Africa 205
Section of Dreikanter Formation in South Notts 209
Section at Snook Point 253
Sketch-map of south-western part of the Isle of Eigg 298
The Sgùrr of Eigg 300
Bidein Boidheach 302
Geological map of Mallorca 338
Geological map of Menorca 342
Neuropteris heterophylla 387
Section at Great Shunner Fell Well, Yorkshire 391
Section through pore in front of eye-lobe of Trilobite 394
Footprints of *Cheirotherium* 396
Restoration of *Plateosaurus* 398
Chelichnus 400
Dreikanter from Upper Permian 401
Fossiliferous Chert beds, Aberfoyle 403
An obscure Graptolite from Aberfoyle 404
Portion of edge of *Typhacites Kitsoni* 435
Ground-plan of cliffs and banks in Arish Mell 452
Scalpellum parvulum, sp. nov. 495
Section with laterite, Mozambique 531
Section with laterite, Mozambique 532
Tabular flint notched out by pebbles 552



H. L. H. del.

Enlarged drawing showing the positions and relations of the pits of the adoral surface in some Holectypoida.

Fig. 1, × 6; Fig. 2, × 6; Fig. 3, × 11.

THE
GEOLOGICAL MAGAZINE
NEW SERIES. DECADE VI. VOL. I.

No. I.—JANUARY, 1914.

ORIGINAL ARTICLES.

I.—Some Problematical Structures in the Holectypoida.

By Herbert L. Hawkins, M.Sc., F.G.S., Lecturer in Geology, University College, Reading.

(PLATE I.)

During a detailed examination of the tests, and in particular of the ambulacra, of the common British species of the Echinoidea Holectypoida, I have found two series of structures the correlation of which, with those known in recent forms, seems difficult. Since I am engaged in the preparation of a description of the British Pygasteridæ, I have thought it advisable to publish now an account of these peculiar features, in the hope that others may be able to throw light on points that seem to me obscure.

The structures to which attention is drawn are both of the nature of sculptured pits on the coronal plates, and seem to be restricted to the adoral surface. One series of pits is ambulacral in position, the other interambulacral. The former series is not associated with any neighbouring peculiarities; the latter is so situated that it seems to be in some way connected with the external branchiæ. The former set of pits is very minute, and is, I believe, recorded for the first time; the latter is often quite conspicuous, and has been figured frequently, usually without comment, by previous observers. I have found no traces of either series of pits in *Conulus*, but both are present in *Pygaster* '*semisulcatus*', *P.* '*umbrella*', *Holectypus depressus*, *H. hemisphæricus*, *Coenholectypus serialis*, and *Discoidea cylindrica*. The succeeding remarks are based solely on an examination of those species.

I. The Ambulacral Pits.

These I noticed first in *P.* '*semisulcatus*', but found subsequently to be more conspicuous in *H. depressus*, and most strongly marked in *C. serialis*.

The ambulacral plates of the Holectypoida are always potentially triads, on one member of which stands a prominent tubercle belonging to the main (ambulacral) series. When compression of the plates occurs, the one with the large tubercle generally remains of considerable size, the plate immediately above it becomes a demi-plate, while that below it, while often retaining its primary character, loses in height and may become cuneiform (see Pl. I, Fig. 2). In *Discoidea* and *Conulus* this plate becomes completely severed from the perradial suture (see Pl. I, Fig. 3). In *Pygaster* the pore-pair of this lowest plate of the triad is generally further removed from the adradial suture than is the case with the other two. Whenever the pits under consideration can be seen, they are found to

occur on this plate, and therefore are situated adorally to the areolæ of the large tubercles.

In *P.* '*semisulcatus*' (Pl. I, Fig. 2), counting from the peristome, two triads in each column of the ambulacra are normal, but the succeeding five show the structures in question. On the lowest plate of each of these five triads, almost impinging upon the peripodium, is a minute, crescent-shaped depression. The horns of the crescent point obliquely adorally and adradially, and between them, where the depression is becoming shallow, there is a minute granule. As far as can be seen, this granule is similar in shape and size to those of the ordinary parts of the plates. But whereas all the ordinary granules may be said to have an axis at right angles to the test surface, these slightly sunken ones have an axis sloping away from the peristome, directed more or less into the depression on whose brink they stand. On the side of each depression, away from the peripodium, there is constantly a small tubercle, the persistent occurrence of which is noteworthy in view of the apparent irregularity in distribution of such tubercles in other regions. It seems to indicate that the structures associated with the depression were sheltered beneath a specially placed secondary radiole.

Owing to the superficial nature of the depressions very well-preserved specimens are necessary for their perception, but I have been able to satisfy myself that they are constant in number and position in five examples of *P.* '*semisulcatus*' in my collection. It seems likely that their characters are similar in *P.* '*umbrella*', but in the material at my disposal they are not very clearly shown.

Pits of a like distribution and nature occur in *Holectypus depressus* and *H. hemisphæricus*, but their numbers seem to be variable, even on the ambulacra of a single specimen. This irregularity may, however, be due to imperfect preservation.

In *Coenholectypus serialis* the corresponding pits are much more pronounced (Pl. I, Fig. 1). The only specimen in my collection (now transferred to the geological department, University College, Reading), of which the peristomial region is exposed, is slightly weathered, and all but the larger surface features have been destroyed. In spite of this the pits are clearly visible, particularly after the specimen has been stained with dilute Indian ink. As in *Pygaster*, two more or less complete triads (counting from the peristome margin) seem to be devoid of pits. These when they occur are fewer in number than in the Oolitic genus, there being only three in each area, except in amb. V, where there are four, two in each column. They show no signs of being crescentic in shape, but seem roughly elliptical in plan, and uniformly depressed throughout. No granules can be seen in them, but since all such structures have been destroyed on the rest of the test, it is fair to assume that they were present. The distribution of the pits is interesting. There are two in columns Ia, IIa, IIIb, IVa, Va & b, and one only in columns Ib, IIb, IIIa, IVb. It will be noticed that, except in area V, the occurrence of the pits is in strict accord with the order of plate-development as determined by Lovén (*Études*, p. 13).

In *Discoidea cylindrica* (Pl. I, Fig. 3) the pits are far less deep, even than in *Pygaster*. Indeed, it was not until I was drawing an ambulacrum of this species under a high power of magnification with specially arranged lighting, and examining each granule separately, that I discovered them. Unfortunately none of the material I have yet seen is sufficiently weathered around the invaginated peristome to give a clear view of the adorally situated plates. But, although the lower plates of the triads are demiplates, and of very restricted area, the four next outside the border of the invagination show the pits. They are crescentic, and similar, save in point of size, to those of *Pygaster*.

Whatever may be the significance of these pits, and however much the extent of their distribution may be enlarged by further research, I feel confident that they have essentially the positions indicated above, and that nothing like them occurs on the other plates of the triads. The nearest approach to them seems to be found in the sunken tubercles met with on the adapical surface of the Cornbrash form of *Holectypus depressus*, but those are on the interambulacral plates between the central tubercles of the main series (see Hawkins, Geol. Mag., 1911, p. 444, Fig. 1, H). The restriction of the pits in question to the ambulacra at once suggests a comparison with the pockets for sphæridia, and this is the only suggestion as to their meaning that I can offer. Their arrangement (in reduced numbers) in *C. serialis* is strongly reminiscent of the distribution of the sphæridia in *Echinonëus* (Westergren, 1911), and the presence of four of them in one area would seem to compare with the four sphæridia figured by Lovén (*Études*) for that genus. But very great difficulties are encountered if the comparison between the pits of the Holectypoida and sphæridia be carried further. In *Pygaster* and *Discoidea* they extend to a considerable distance from the peristome, and seem not to occur in its immediate neighbourhood. It is true that in many advanced Spatangoids sphæridia, or at least their pits, occur at an even greater proportionate distance from the peristome, but they occur on every plate, there being no intervening plates as in the Holectypoids.

A comparison is possible between these pits and the curious sunken granules (bearing 'glassy tubercles') in *Echinonëus*, and the probably similar pits that occur thickly scattered over the test of *Conulus*. However, the restricted distribution of these ambulacral pits seems to point to some more special and localized function than could be ascribed to glassy tubercles.

As the matter stands at present, these depressions would seem to be either the pits for sphæridia (in which case their distribution is unique) or some special structure not yet recognized in recent forms.

II. The Suprabranchial Depressions.

In all the Holectypoida, with the partial exception of *Conulus*, the branchial slits make conspicuous indentations on the margin of the peristome, the deepest part of the incision being situated just in the interambulacrum. Passing from the peristome, near the adradial suture, but separated from it by a row of fairly prominent

tubercles and granules, is a slightly depressed groove that extends over about four of the interambulacral plates. This groove is generally smoother than the surrounding parts of the test, and the granules occurring in it are often unlike those outside. In *Pygaster* they are usually abundant and minute, most of them being transversely elongated. In *Holectypus*, and particularly in *H. depressus*, they are relatively few in number, of fairly large size, and guttate in plan, tending to radiate from the areolæ of the main tubercles. In *Discoidea* there is hardly any difference between the granulation of the groove and that of the surrounding regions.

At the places where the 'suprabranchial groove' crosses the transverse sutures there are developed elongate depressions. Three such hollows commonly occur in each groove, those nearest to the peristome being usually the most deeply excavated. They are completely devoid of granules, and in the case of *Discoidea* are each surrounded by a smooth, ovoid area, flush with the test surface. The pits are more deeply cut in *Coenholectypus serialis* than in any other form I have examined (Pl. I, Fig. 1). Here they are more or less pyriform in outline, the pointed end being directed towards the adradial suture.

The fact that the shallow grooves into which these depressions are trenched seem to originate at the branchial slits, makes it probable that they must have some function connected with the external branchiæ. However, the distance to which the grooves and pits extend from the peristome is far greater than one would expect the branchiæ themselves to traverse. In most regular Ectobranchiates the 'gills' are small bunches of vascular tubes that hardly project beyond the peristomial membrane, and they are protected from the radioles and pedicellariæ of the adjoining plates by a smooth lip-like area. A similar 'lip' is present in the Holectypoida, so that it seems probable that the nature of the 'gills' was also similar.

The curious guttate and elongate granules of the suprabranchial groove may perhaps have supported pedicellariæ of a special kind that would act as 'gill-rakers'; but this supposition of course involves the capability of such organs for reaching the branchiæ. But I can suggest no function or meaning for the depressions along the sutures in this region. Their invariable presence, and frequently considerable depth, seem to indicate that they are structures of some physiological importance. They resemble the sutural excavations common among the Temnopleuridæ (these occur in at least one Holectypoid genus, *Coptodiscus*). Whatever may be the value of the pits in those forms, the restriction of these depressions to the suprabranchial groove must indicate a more localized function. They are certainly quite different from the ambulacral pits above described. The latter are *on* the plates, not between them, and contain a granule, whereas the suprabranchial pits are particularly smooth.

To sum up: the Holectypoida (except *Conulus*) possess two series of excavations on the test near the peristome. One series, ambulacral in position and regularly situated with regard to the triads, may possibly have lodged sphæridia, although there are many difficulties met with in such a view. The other series is interambulacral,

placed on the transverse sutures in the suprabranchial groove. For this no function can be suggested, but it is hoped that future work, particularly on recent material, may throw some light on the problems here stated.

EXPLANATION OF PLATE I.

The figures have been drawn with the help of photographs, copied by means of an Edinger Projection apparatus. The ambulacral pits and suprabranchial depressions are represented in black for the sake of clearness, but must not be confused with the actual perforations of the test. The figures are not diagrammatic in any other way.

FIG. 1. Adoral surface of a small specimen of *Coenholectypus serialis* from the Senonian of Algiers (Univ. Coll., Reading, Geol. Museum, No. F. 284). × *c.* 6. The ambulacral pits are seen to occur in series conformable to Lovén's law, except in area V. The interambulacral depressions are pyriform, pointing adradially.

FIG. 2. Part of the adoral region of amb. III of *Pygaster 'semisulcatus'*, with the adjoining parts of the interambulacra. × *c.* 6. The ambulacral pits are crescent-shaped depressions (each enclosing a small granule) seen near the peripodium on the lowest member of each triad (except the two proximal ones). The interambulacral depressions are conspicuous, and the granules of the suprabranchial groove are seen to be transversely elongate and arranged in a linear fashion.

FIG. 3. Part of the adoral region of amb. I of *Discoidea cylindrica*, with the adjoining parts of the interambulacra. × 11. The lower part of the figure coincides with the beginning of the peristomial invagination. The ambulacral pits are similar to those of *Pygaster*, but much smaller in proportion. The suprabranchial depressions are also smaller, and are surrounded by an area devoid of granules.

II.—On *Herpetopora*, a New Genus containing three New Species of Cretaceous Cheilostome Polyzoa.

By W. D. Lang, M.A., F.G.S.

(PLATE II.)

In a report[1] on a visit of the Geologists' Association to the exhibits of Polyzoa and Corals in the Geological Department of the British Museum in February, 1913, the author had occasion to mention two related and unnamed species of uniserial Chalk Polyzoa that hitherto had appeared in records as *Hippothoa dispersa* (von Hagenow), neither of which was this species, nor did either belong to the genus *Hippothoa*, Lamouroux.[2] Since one of these two forms is very common in the English Chalk and the other not rare, it is time for a description of them to be published, that collectors may have distinctive names for them. In addition, a third form that has occurred in England is described, and the rest of the species included in the genus are mentioned, so that an idea of the genus as a whole may be formed.

Herpetopora,[3] n.gen.

Diagnosis.—Incrusting, uniserial, Cheilostome Polyzoa, in which each individual normally has either a distal or one distal and two

[1] Proc. Geol. Assoc., vol. xxiv, pt. iii, pp. 171–2, 1913.

[2] Lamouroux, *Exposition Méthodique des genres de l'Ordre des Polypiers*, 1821, p. 82. The genotype is the recent *Hippothoa divaricata*.

[3] *το ἑρπετόν*, 'a creeping thing.'

lateral buds, so that the normal mode of branching is 'bilateral'; no avicularia, but heteromorphic individuals may occur; normal zoœcia consisting of a distal 'capitular' and a proximal 'caudal' portion, though in young zoarial stages, as evidenced by recapitulation at the branches, the caudal portion is very short or absent; front wall divided by a plain, more or less oval rim, the 'termen', into an inner and outer portion—the intra-terminal and extra-terminal front walls; the former consists of a narrow, calcareous terminal bevel, hardly wider proximally than distally, and (presumably) of a chitinous portion not preserved in the fossil state; extra-terminal front wall entirely calcareous, plain, with no median proximal ridge or groove. Sealed and renewed zoœcia very common.

Note.—*Hippothoa*, in which the two following species have hitherto been placed, has a completely calcareous front wall.

Genotype.—*Herpetopora anglica*, n.sp.

HERPETOPORA ANGLICA, n.sp. Pl. II, Figs. 1–3.

Diagnosis.—*Herpetopora* with zoœcia that taper somewhat distally as well as proximally; with regularly elliptical termens and (in ephebastic zoœcia) with very long, straight caudal portions. Heteromorphic individuals of unknown function, but not avicularia, occasionally occur.

Note.—The distal tapering distinguishes *H. anglica* from pear-shaped forms such as *H. clavigera*, n.sp., *Hippothoa cruciata*, Reuss,[1] and *H. gracilis*, d'Orbigny,[2] and the regularly elliptical termens and straight caudal portions from *H. labiata*, Novak,[3] and *H. desiderata*, Novak.[4] *Cellepora dispersa*, von Hagenow,[5] to which this form is usually referred, is not even a *Herpetopora*. It has a beaded termen and definite avicularia on the caudal portions of the zoœcia; it is found in the *mucronata* zone at Rügen.

Type-specimen.—British Museum specimen D. 11359; Senonian, top of zone of *Micraster cortestudinarium* or base of zone of *M. coranguinum*; Chatham, Kent; W. Gamble Collection.

Distribution.—Turonian, zone of *Terebratulina*, to Senonian, zone of *Marsupites*. Common in zone of *Micraster cortestudinarium* and in lower part of zone of *M. coranguinum*.

HERPETOPORA CLAVIGERA, n.sp. Pl. II, Figs. 4–5.

Diagnosis.—*Herpetopora* with zoœcia hardly tapering distally and consequently more or less pear-shaped, having their outlines bounded by steeply curved sides, more so than in *Hippothoa cruciata*, Reuss,[6]

[1] Reuss, Denk. d. Kaiserl. Akad. d. Wissensch. Wien, Bd. vii, p. 134, pl. xxviii, fig. 1, 1854.

[2] D'Orbigny, *Paléontologie Française; Terrains Crétacés*, vol. v, p. 386, pl. 711, figs. 9–11, 1852–3. It is very doubtful whether this form should be placed here.

[3] Novak, Denk. d. Kaiserl. Akad. d. Wissensch. Wien, Bd. xxxvii, pt. ii, p. 86, pl. iii, figs. 1–5, 1877.

[4] Novak, op. cit., p. 86, pl. ii, figs. 1, 2, 1877.

[5] Von Hagenow, 1839, *Neues Jahrbuch f. Min.*, etc., p. 280. For figure see Marsson, *Pal. Abhandl.*, Bd. iv, Hft. i, p. 91, pl. ix, fig. 9, 1887.

[6] Reuss, loc. cit.

which has them gently curved, and *H. gracilis*, d'Orbigny,[1] in which the sides are nearly straight.

Type-specimen.—British Museum specimen, D. 20607; Senonian [zone of *Belemnitella mucronata*]; Norwich; T. G. Bayfield Collection.

Distribution.—Senonian, above the zone of *Marsupites*.

HERPETOPORA DANICA, n.sp. Pl. II, Figs. 6–7.

A third species of *Herpetopora* is represented by two specimens in the British Museum from the Danian of Faxe, Denmark; and another specimen from the *mucronata* zone of Norwich is in the collection of Dr. Rowe, who kindly lent it to me for examination and description. Other species which probably should be placed in this genus are *Hippothoa labiata*, Novak, from the Cenomanian of Bohemia; *H. desiderata*, Novak, from the lowest Senonian of Bohemia; *H. cruciata*, Reuss, from the Turonian of the Austrian Tyrol; and *H. gracilis*, d'Orbigny, from the Senonian of Tours, Indre-et-Loire.[2]

Diagnosis.—*Herpetopora* with large zoœcia tapering somewhat distally, with oval rather than elliptical[3] termens, and with very short caudal portions.

Remarks.—The shorter termens and caudal portions as well as the large size of the zoœcia distinguish *H. danica* from *H. anglica*, which it otherwise resembles.

Type-specimen.—British Museum specimen, D. 19429; Danian; Faxe, Denmark; J. W. Davis Collection.

Distribution.—Senonian, zone of *Belemnitella mucronata*; Thorpe St. Andrew, Norwich (A. W. Rowe Collection). Danian; Faxe, Seeland, Denmark (British Museum specimens, D. 19429, D. 9113, J. W. Davis and Miss Caroline Birley Collections).

KEY TO THE GENUS *HERPETOPORA*.

A. Zoœcia tapering at both ends.
  1. Termen regularly elliptical or oval; zoœcia with caudal portions very straight.
    a. Termen oval rather than elliptical; caudal portions of zoœcia very short or absent . . . . . *H. danica*
    b. Termen elliptical rather than oval; caudal portions of zoœcia very long (except as a neanastic character) . *H. anglica*
  2. Termen irregularly elliptical; capitular and caudal portions of zoœcia slightly wavy . . . . . *H. labiata* (Novak)
  3. Termen irregularly elliptical; zoœcia, especially the caudal portions, wavy; zoœcia sometimes tend towards a pear-shape as in B . . . . . *H. desiderata* (Novak)

B. Zoœcia tapering proximally and ending fairly abruptly distally.
  1. Proximal capitular parts of zoœcium bounded by nearly straight lines . . . . . *H. gracilis* (d'Orbigny)
  2. Proximal capitular parts of zoœcia bounded by gently curved lines . . . . . *H. cruciata* (Reuss)
  3. Proximal capitular parts of zoœcia bounded by sharply curved lines . . . . . *H. clavigera*

[1] D'Orbigny, loc. cit.

[2] For references to the original descriptions of these species see footnote under *Herpetopora anglica* on p. 6.

[3] Oval and elliptical used in the botanical sense, as defined, for instance, in Asa Gray, 1879, *Structural Botany*, p. 95.

FIG. EXPLANATION OF PLATE II.

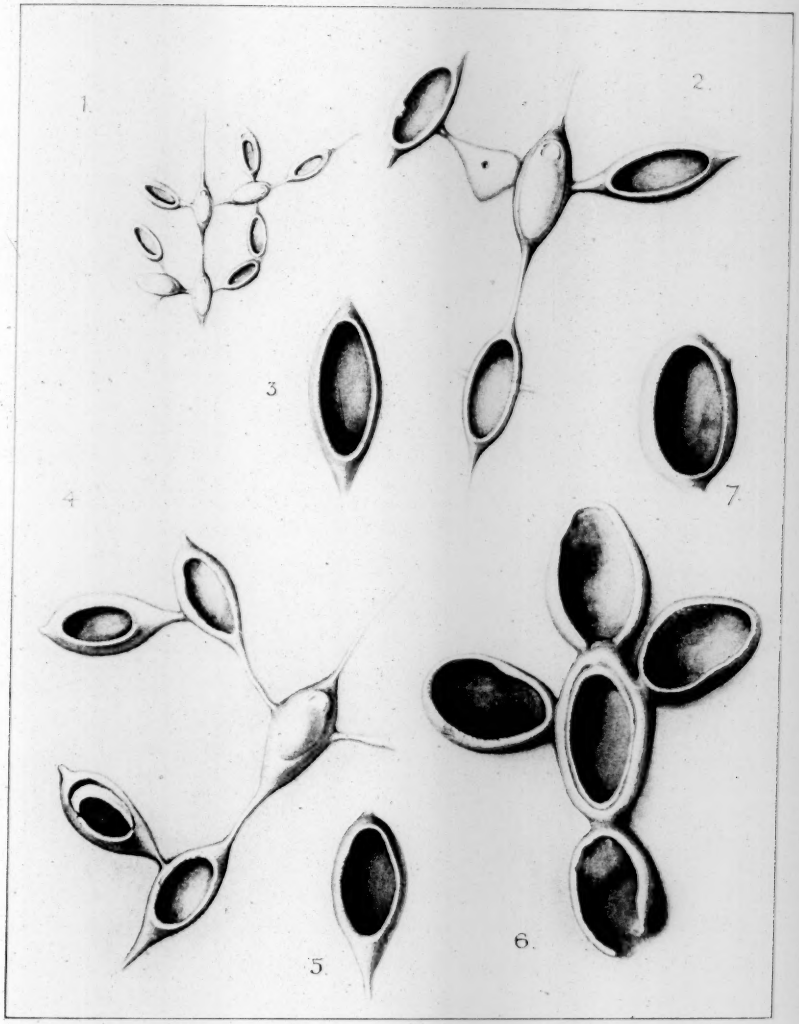
1. *Herpetopora anglica*. A piece of zoarium showing the method of branching typical of the genus *Herpetopora*. Of the ten zoœcia shown four are sealed and three are renewed zoœcia. × about 11 diameters. The type-specimen; British Museum specimen No. D. 11359. Senonian, top of *Micraster cortestudinarium* zone or base of *M. coranguinum* zone. Chatham, Kent. W. Gamble Collection.
2. *H. anglica*. Pieces of two branches of a zoarium, more highly magnified than Fig. 1. One zoœcium is sealed, three are normal, and the remaining zoœcium is a heteromorphic individual of unknown function. × about 27 diameters. Part of the same specimen as Fig. 1.
3. *H. anglica*. A single normal zoœcium still more highly magnified than Fig. 2. × about 33 diameters. The zoœcium is the same as that at the lower right-hand corner of Fig. 1.
4. *H. clavigera*. A piece of zoarium magnified approximately to the same extent as Fig. 2. One sealed and three normal zoœcia are shown; two of the latter are much broken. × about 25 diameters. The type-specimen; British Museum specimen No. D. 20607. Senonian, zone of *Belemnitella mucronata*. Norwich. T. G. Bayfield Collection.
5. *H. clavigera*. A single normal zoœcium from another part of the specimen from which Fig. 4 is drawn, magnified to the same extent as Fig. 3. × about 30 diameters.
6. *H. danica*. A piece of zoarium magnified approximately to the same extent as Figs. 2 and 4, bearing four normal and one renewed zoœcium. × about 24 diameters. The type-specimen; British Museum specimen No. D. 19429. Danian. Faxe, Seeland, Denmark. J. W. Davis Collection.
7. *H. danica*. A single normal zoœcium from the zoarium of which Fig. 6 is a part, magnified approximately to the same extent as Fig. 6. × about 24 diameters.

III.—The value of a knowledge of the Rock-soil Distribution of Plants in tracing Geological Boundaries.

By A. R. Horwood.

THOUGH ecology has been studied for a long period on the Continent it is only within the last ten years that it has become an important branch of botany in this country. Now, however, it is one of the most ardently pursued sciences, and has made great progress. That branch of it which deals with soil factors, or the distribution of plants upon different soils and a knowledge of the nativity of plants upon particular soils, has received considerable attention, and sufficient data have been accumulated to state the principle that each rock-soil supports a characteristic flora: so that the type of soil may be regarded as an index to the type of vegetation of any district where that rock-soil is dominant; and in the same way it is possible to state by a recognition of the type of vegetation the character of the rock-soil.

Whilst emphasizing these main features it should not be forgotten that exceptions occur, and that composite rock-soils are liable to obscure the clear evidence afforded by self soils or those that are pure. But they do not by any means invalidate the importance of these main principles. The influence of man, largely through agriculture, traffic, industry, building, etc., upsets in some cases the normal features noticeable in an undisturbed state of nature. But this is inevitable, and must be taken into account in all biological work.



G. M. Woodward del.

The genus *Herpetopora*.

In using the word rock-soil in a special sense, to denote the soil afforded by any particular rock or geological formation, ancient or recent, by whatever agency formed or accumulated, it should be pointed out that though there are, broadly speaking, quite fifty, if not more, such types, yet the distinctive types of soil which exhibit marked differences in composition, chemical and physical characteristics, are briefly six in number: clay loamy sand, siliceous soils, limestone or chalk, peat (raw or acid), humus (raw or acid), and saline soil. Particularly is the presence of lime in a rock-soil a predominating factor in plant dispersal, so that we speak of calcicole and calcifuge species. The same applies to peat, humus, salt, and in a less degree to clay, sand, and silica, since these last are liable to be frequently mixed in varying proportions, and the existence of marls affords a passage from arenaceous to calcareous types.

If this is so it is obvious that the principles stated (akin to those of William Smith) must have an important bearing upon geology, especially in the possibility of determining thereby, in the field, where palæontological data are wanting, the existence of definite zones and subzones. The very vegetation which to the pure geologist is the cause of obscuring the sequence, may in this way by ecological methods be a means of determining their position, a paradox which, however, is quite intelligible if one bears in mind the principles of Smith that strata are characterized by their organic remains, more particularly so as in the case of plant-bearing formations, such as the Coal-measures, it is possible to show that there was in the past, as in the present, an ecological association of plants, that is to say, that dry soil plants are found as they grew in certain associations, whilst wet soil or aquatic types are found and grew in different positions, or at different horizons, or can be found to have a different geographical distribution. In particular such formations as the Trias (Keuper, Rhætics), the Lias, etc., have intermittent bands of limestone, skerries, etc., which are not always to be seen in the field, in section or otherwise, and in such cases there is often considerable difficulty, especially in faulted regions or where drift obscures the solid rocks, in tracing such beds across country. In the same way the existence of irregular beds of sand in glacial deposits is often obscured by vegetation or other causes, and their existence, and their extent and area, is often a pure matter of conjecture, frequently only to be ascertained by aid of well-borings or other operations of the kind. As the delineation of clay and sand, and the mapping of such details, are of great importance, especially to the builder, agriculturist, and horticulturist, and economic geology is to-day a great factor in survey work, any accessory aids that can be rendered by the ecologist are worthy of the consideration of geologists. And these are only a few of the ways in which a study of rock-soil distribution of plants may serve the geologist in good stead. Moreover, ecology has already advanced so far that surveys upon a systematic and well-organized plan have been made, and exact vegetation maps published, so that it is hoped and expected that this science, which is of such importance from the economic as well as the stratigraphic standpoint, will have shortly to be established upon a national basis, and ecological surveys

carried out by the State. This opinion has, in fact, already been stated by ecologists. This necessity of course arises primarily from the purely ecological value of the work, and since ecology and geology are, as I have shown, interdependent, there is thus additional reason for urging that the former be recognized, as fully as the latter, as of national importance, and therefore worthy of public support of a financial kind.

It is therefore suggested that till this is accomplished, if it meets with approval in this quarter, geological survey work should be definitely carried out in conjunction with ecological surveys. Soil surveys have been made in conjunction with experimental stations at the instance of the Geological Survey, and the further step I advocate in this direction would be of a similar kind and for a similar purpose, though on a wider basis. At any rate it might be possible that those at work in each district, upon ecological surveys, should be asked to co-operate, where required, with geological surveyors, especially in those areas where this co-operation would be of great assistance in tracing boundaries of local beds.

It is further suggested, if this be possible, that a definite effort should be made to accomplish the appointment of Government ecological surveys by those already officially in charge of geological work, in view of the assistance each science can render the other. Whilst emphasis has been laid here on the value of ecology to the geologist equal value is rendered of course by the geologist to ecology, and speaking as a geologist I might even say more. It must not be forgotten that, though little of this figures in literature, there are men who have for long noticed the connexion between plant dispersal and rock conformations in their systematic survey of the geological structure of the British Isles, if I mention only Sir Archibald Geikie and Mr. H. B. Woodward. A few examples of the data afforded by plants as to geological horizons may serve as an appendix to these remarks, but only a brief summary can be given and a selection of certain formations made.

Carboniferous Limestone.—Ash woods are the typical woodlands and would at once mark off a limestone district from a sandy district with sessile oaks as in Derbyshire. In such woods there is a predominance of one or two plants, such as *Mercurialis perennis*, *Adoxa moschatellina*, *Lamium galeobdolon*, etc. The open grass land of the massifs is characterized by such plants as *Reseda luteola*, *Arenaria verna*, *Geranium lucidum*, *Anthyllis vulneraria*, *Saxifraga tridactylites*, *Sedum acre*, *Helianthemum*, *Galium asperum*, *Origanum vulgare*, *Thymus serpyllum*, *Habenaria viridis*, *Allium vineale*, *Koeleria*, *Brachypodium pinnatum*. Where these plants occur, if no exposures were available, limestone could be mapped, and even if only one or two of the specially characteristic plants occurred this would be enough, so strong is their attachment to lime soils and their absence so well marked upon others.

In the case of the Keuper the uniform marl tracts are characterized more especially as being really more clayey and loamy than marly by oak woods with a particular ground flora. But the flora is rather an ordinary type, and is valuable in indicating rock formations where two

different formations are exposed, as where Pre-Cambrian rocks with birch wood and *Aira flexuosa* adjoin red marl tracts. A feature of the sandstones is the occurrence of such arenophilous plants as *Erythræa*, and where the soil is more calcareous, of *Scabiosa columbaria* and *Gentiana amarella*.

In the case of the Rhætics the outcrop is so small and the individual beds so thin that plants are not confined to a zonal arrangement as in the overlying Lias.

In the Lower Lias there are limestone bands which may be indicated by such plants as *Poterium sanguisorba*, *Pimpinella saxifraga*, *Caucalis nodosa*, *Carum segetum*, *Carduus nutans*, *Cnicus acaulis*, etc.

Ironstone bands, or beds rich in iron, are indicated by the dominance of *Rumex acetosa*.

Clayey beds are revealed by the predominance of *Ranunculus ficaria*, *Lotus corniculatus*, *Conopodium denudatum*, *Scabiosa succisa*, *Tussilago*, *Petasites*, *Juncus conglomeratus*, *Rhinanthus*, *Ajuga*.

In the *Margaritatus* beds there are sandy horizons which are characterized by *Ulex*, *Stellaria graminea*, *Galium saxatile*, *Polygala vulgaris*, *Mercurialis perennis*, *Potentilla erecta*.

Some more clayey beds are indicated by *Pedicularis sylvatica*, *Lamium galeobdolon*, *Primula vulgaris*, *Saxifraga granulata*, *Galium uliginosum*.

Lime bands are indicated by *Reseda luteola*, *Silene noctiflora*, *Poterium sanguisorba*, etc. In the Rock-bed there are sandy beds upon which *Erophila vulgaris*, *Cerastium semi-decandrum*, *Geranium molle*, *Taraxacum erythrospermum*, *Myosotis versicolor*, *Veronica arvensis* are particularly abundant. On the purely clayey beds *Cerastium glomeratum*, *Malva moschata*, *Trifolium repens*, *Lathyrus pratensis*, *Anthriscus sylvestris*, *Stachys sylvatica*, *Tamus communis*, etc., are characteristic.

The Chalk plants *Papaver Rhœas*, *Viola hirta*, *Poterium sanguisorba*, *Echium vulgare*, *Linaria vulgaris* indicate bands of limestone, and so also do the following limestone plants: *Pimpinella magna*, *Centaurea scabiosa*, *Avena pratensis*, *Koeleria cristata*. It is generally characterized by *Myosotis collina*, *Cerastium arvense*, *Carduus nutans*, *Malva moschata*, *Chrysanthemum segetum*, *Scabiosa arvensis*, *Caucalis nodosa*, *Thymus serpyllum*, *Galeopsis Tetrahit*, *Silene noctiflora*.

The Inferior Oolite is characterized by beech and ash woods generally. Typical plants are *Helianthemum chamæcistus*, *Asperula cynanchica*, *Hippocrepis comosa*, *Campanula glomerata*, *Verbascum lychnitis*, *Carduus nutans*, *Carlina vulgaris*, *Calamintha acinos*, *Centaurea scabiosa*, *Filago germanica*, *Galium mollugo*, *Anemone pulsatilla*, *Geranium columbinum*, *Orchis pyramidalis*, *O. ustulata*, *Scabiosa columbaria*, *Galium erectum*, *Ononis repens*, *Origanum vulgare*, *Cephalanthera rubra*, *Senecio campestris*, *Herminium monorchis*, *Bromus erectus*, *Brachypodium pinnatum*.

The flora of the Northampton Sand is akin to that of the Marlstone, and *Scabiosa arvensis*, *Senecio Jacobæa*, *Centaurea scabiosa*, *Carduus nutans* distinguish it from that of the Upper Lias.

Boulder-clay consists in a large measure of clay with irregular patches of sand. These can be distinguished by the plants which respectively prefer clay or sand. On clayey beds the following are

more prevalent: *Heracleum sphondylium, Lotus corniculatus, Potentilla anserina, Tussilago Farfara, Ranunculus bulbosus, R. repens, R. ficaria, Cardamine flexuosa, Lychnis dioica, Arenaria trinervis, Oxalis acetosella, Vicia cracca, Circæa lutetiana, Sanicula europæa, Dipsacus sylvestris, Nepeta glechoma, Rumex viridis, Arum maculatum, Deschampsia cæspitosa, Bromus asper*, etc.

The sandy beds are well distinguished by the occurrence of such plants as *Rumex acetosella, Aira præcox, Hypochæris radicata, Crepis virens, Linum catharticum, Cerastium triviale, Festuca ovina, Agropyron repens, Rubus rusticanus, Plantago media.*

The plants of alluvial ground are also very characteristic, consisting largely of marsh or wet meadow plants, chiefly of northern origin. The following are useful in the recognition of alluvium: *Spiræa ulmaria, Veronica beccabunga, Caltha palustris, Cardamine pratensis, Phalaris arundinacea, Poa trivialis, Apium nodiflorum, Juncus glaucus, J. effusus, Carex glauca, C. riparia, C. paludosa*, etc., *Alopecurus geniculatus, Geranium robertianum*, etc., *Mentha hirsuta.*

IV.—On Lifting by Ice-melting.

By the Rev. Edwin Hill, M.A., F.G.S.,
late Fellow of St. John's College, Cambridge.

EVERYONE knows that ice floats in water, is able to carry some amount of materials attached to it, and if lifted by rise of the water-level is able to lift them with itself. Lyell describes this in the *Principles* (ch. xvi, xxxi), and probably it is mentioned in every textbook. But ice is also able to lift attached materials without rise of the water-level. It requires no tides, no floods; it can lift without external aid, by its melting alone.

When a crust of ice 1 foot thick has formed on a sheet of fresh water it floats with its upper surface about an inch above water-level, its lower surface about 11 inches below.[1] If by any cause this ice-crust is melted over its upper surface, the products of melting flow off, the upper surface sinks a little, but the lower surface rises through about eleven-twelfths[2] of the thickness melted off. Take an ice-floe uniformly 6 feet thick: its lower surface will be floating, if the water be fresh, at about 5½ feet below water-level. Suppose it reduced by melting over the upper surface till only 6 inches thick, the lower surface will now be about 5½ inches below water-level; this lower surface will accordingly have risen more than 5 feet. If any objects or materials were attached to that lower surface they will have risen with it: they will have been lifted. This is undeniable and obvious. It is undeniable and obvious that ice is able to lift materials by simple melting, independently of any other power or action.

An ice-crust may be conceived as melted only over the upper surface. It seems not unlikely that most of the melting takes place

[1] With ice of sp. gr. ·918, ·984 inch above, 11·016 inches below. Captain Scott thought that the ice of Antarctic bergs may be much lighter (*Voyage of Discovery*, vol. ii, p. 411).

[2] 11·016 out of 12.

over the upper surface. Sun heat attacks only the upper surface; wind and rain attack only the upper surface; the flow off from melting will not for some time have any melting power. Even a warmer current, so long as water above freezing is denser than water at freezing, is likely to pass below the water in contact with the ice: the lower surface will be likely for a while to escape its influence. In considering only cases of melting from the upper surface we shall be considering, I think, a large majority of the cases which actually occur. That ice does melt on its upper surface every skater knows by experience of thaw, and accounts of Polar explorations describe summer alterations of the surface even in the regions of greatest cold. Wherever ice is formed melting must be very frequent. There are incessant alterations of temperature, by changes of wind and cloud, by changes of night and day, by changes of winter and summer. Melting is an action of very frequent occurrence. Lifting by melting must be a very frequent result. It may produce a variety of consequences, according to the variety of circumstances.

In shallow waters the ice-crust will, over parts, touch the bottom. Parts of the sodden bottom may, and doubtless will, be frozen to it, will when its surface melts be lifted by it, may when it breaks up and floats away be carried away with it. From a bottom undulating in ridges or mounds, if the ice be in contact with such ridges or mounds, the highest parts will be lifted and removed. Thus the depth will be made more uniform; the effect will be as if tops were planed away. The bottom will be levelled and the average depth increased. Ice melting and lifting is an agent of levelling and of denudation.

When the ice floats away materials attached to it will be floated away: the ice melting and lifting will become an agent of transportation. If a portion strands, where it rests the attached materials may rest. If a portion melts, where it melts the attached materials may be deposited. Ice melting and lifting will have become an agent of deposition.

When an ice-crust has enveloped any objects projecting from the bottom, as it rises it tends to pull them up. The lifting power of flotation is well known: it has been employed to tear up piles, barges lashed to them raising them with a rising tide. An ice-crust melting exerts the same action. Horizontal force on such objects would be resisted by the strength of the matrix in which they are embedded; but vertical lift is resisted only by their weight and adhesion. Ice melting and rising exerts the action which has been attributed to glaciers under the name of 'plucking', and exerts it in the most favourable direction.

When an ice-crust forms against a bank or cliff portions will adhere to it: portions may be broken away as it rises, and will be carried away if it moves. This action will steepen banks and undermine cliffs. It is the action which has been attributed to glaciers under the name of 'sapping'.

Ice melting and lifting will elevate. Boulders attached to its under surface will rise with that surface, and if stranded will be left

at a higher level. The elevation by a single operation cannot exceed the thickness of the ice. But where land is sinking repetitions of the operation might elevate to the total extent of subsidence. Also, any snowfall will sink the ice by its superincumbent weight.[1] Should the periodic snowfall exceed the periodic melting the under surface will continue to sink. In an ice-age lakes thus easily may, probably will, become solid masses of ice. When milder times return materials from their very bottoms may be brought to their surfaces.

On land, when ice filling a rock-basin moves through it, materials may be moved from the lower levels to the level of outflow. But even when the ice does not move through, on melting it may bring up materials from the very bottom to the surface.

When an ice-floe with attached pebbles or rock-fragments strands, scratches and striations on pebbles, fragments, and bottom may result, as has often and long ago been suggested.

This action of ice-lifting by melting should produce its maximum effects in groups of conditions, different for different effects. For removal of material, planing down, denudation in general, the most favourable conditions while climate remains unaltered seem to be, a land undergoing alterations of level; either rising, whereby fresh bottom is being brought within reach of the ice, or sinking, whereby fresh stretches of margin are being submerged.

In lifting boulders to points above their place of origin, the greatest possible lift is from the lowest point reached by ice in the period to the highest.

For accumulation of a thick deposit favourable conditions seem, a wide area of shallow water alternately frozen and thawed, which should drain into an area of warmer water sufficiently deep.

The action described does not necessarily require a low mean annual temperature. Favourable conditions would be, severe winter cold, with summer warmth sufficient to melt ice at the surface and to break it up. The action would be vigorous during the incoming of a glacial period. When cold grew so severe that there was no summer break up the action might cease, but would recommence when the cold began to pass away. During every part of such period the action, though suspended over the interior of the cold area, would probably still be going on over the outskirts. Even now it must be going on in several parts of the earth.

The amount of work which could be done in this way might be considerable in a sufficient time. Thousands of years are claimed for the durations of ice-ages: if so, work done in them should be the average work of a year multiplied by thousands. An ice-raft able to support an inch of material would not need to be very thick. Anything attached to the lower surface would be buoyed up by the water and lose part of its weight. Consider material of sp. gr. 2·50. An inch-thick layer on the upper surface would require about 30 inches of ice, but if attached below could be supported by about

[1] Scott's *Voyage of Discovery*, vol. ii, p. 458. Shackleton's *Heart of Antarctic*, vol. ii, p. 289. Also Lyell's *Principles*, ch. xi (there of drifted snow).

20 inches only.[1] A 6 ft. thick ice-sheet, after three-fourths had melted away, could still transport a layer of nearly an inch.

"The thickness of floe ice in Baffins Bay is said to average 5 or 6 feet: elsewhere it is much thicker" (Bonney, *Ice-work*, p. 62). In the Gulf of Bothnia also it is 5 or 6 feet (Lyell, *Principles*, ch. xvi). In the Antarctic Captain Scott estimates it as "in exposed sea under 8½ feet; where land precludes rapid circulation of water as much as 10 feet by freezing alone; where snow accumulates any thickness may be produced" (*Voyage of Discovery*, vol. ii, p. 458). In Shackleton's *Heart of the Antarctic*, vol. ii, p. 277, the maximum thickness of sea ice is given as 7 feet.

If a Glacial period began over our present England, would not these effects be produced in such shallow sheets as some of the Norfolk Broads? If subsidence should also occur, the Fens and other low-lying tracts would experience the action. Many inland areas are broad and level; they, too, would be brought under it. Imagine the Vale of York water-covered while ice-age temperatures prevailed; would not much of its surface be lifted and carried into the Humber? Would not the Humber Estuary be kept filling up, and kept filling up with material like the matrix of the Holderness Clays?

Some peculiar features of some Glacial formations are what might be expected if this action had been at work.

Objects frozen to the bottom of an ice-crust, lifted and dropped without stranding, would suffer no friction, no abrasion, no crushing. Even should the ice strand, such objects being firmly frozen would be in circumstances favourable for escaping injury. Ice lifting from a bottom would lift its burden whole. By its thaw the most delicate shells might be deposited without chip or scratch.

In stranding, as has been said, objects attached to the lower surface might be scratched. Also at the beginning of flotation there would probably be some movement before complete removal. Such also would grind or scratch. In the Chalky Boulder-clay the pieces of chalk are mostly rounded, many scratched.

Sedimentation in moving water is expected, ordinarily, to increase in amount with the depth. Sedimentation from ice-rafts would not be governed by depth. It would depend on the distribution over the surface of such rafts, their loads, and their melting. If distribution were uniform, deposit would be uniform; it would cover the bottom with a mantle of uniform thickness over plateau and valley alike.

Material would be lifted in sheets, and might be so dropped. Sheets, streaks, and pockets are frequent in Boulder-clays. I find it easier to conceive even the long sheets of chalk in the Cromer cliffs to have been lifted and dropped, than to be consequences of displacement by thrust. Certainly, an ice-floe which could bear up a strip of chalk 120 yards long and 10 deep (there is one such near Runton) must have been large. But a floe twenty times its volume would be large enough, and what would that be in Polar seas?

This paper treats of an action which would go on under water

[1] This in fresh water. For salt water the necessary thicknesses would be less: about 25 and 15 respectively. With ice as light as Captain Scott's estimate they would be smaller still.

during an ice age. Other actions might go on under water, and others would go on at the same time over land above water. These are not considered here.

Lyell seems to have realized the action when he writes (*Principles*, ch. xvi, near end): "In . . . the Baltic . . . the surface freezes over to the depth of 5 or 6 feet. Stones are . . . frozen in . . . and lifted up on the melting . . . in summer." I have not noticed any other recognition.

The agency of ice forming on water and melting, gaining in thickness and losing, is thus able to denude, deepen, plane down, score, striate, 'pluck,' 'sap,' deposit, fill up, elevate, lift to heights. Not only is it able but it must perform these operations, whenever certain conditions combine. All these conditions have existed in the past, and now exist in separate regions of the earth: they can hardly be supposed to have never combined. Such an agency ought not, in speculations, to be altogether left out of account.

V.—The Boring at Heathfield, Devon.

By A. J. Jukes-Browne, F.R.S., F.G.S.

THE geological importance of this boring lies in the fact that it is the deepest which has yet been made in the Bovey Basin, that the site is nearly in the middle of that basin, and that it is evidence of the great depth of the syncline or trough in which the Bovey deposits lie. Although it did not reach the base of these deposits it is highly desirable that we should know the exact depth to which it was carried, as it is the only means of estimating the minimum depth of the basin.

An account of the boring was communicated to me in 1908 by Messrs. Candy & Co., of Heathfield, and was published in this Magazine for June, 1909. As the boring was made for Messrs. Candy and Co. at their Heathfield Potteries, and as they would naturally keep a record of the main facts, I had every reason to suppose that the account which they supplied was correct so far as it went. They informed me that the boring was commenced on the floor of their large open pit, and was carried down to a depth of 456½ feet. They also stated that the depth of the pit was, and is, about 70 feet, so that the total depth from the surface of the ground to the bottom of the boring would be 526½ feet. This agrees very closely with the statement which they had previously made to Mr. H. B. Woodward in 1900 and published by him in that year. There is no doubt that the record preserved at the office of the firm shows those figures as the total depth.

It was therefore with much surprise that I found quite a different account of this boring given in the recently issued memoir of the Geological Survey on *The Country around Newton Abbot*. In this memoir the chapter on Tertiary Deposits is written by Mr. C. Reid, and he seems to have ascertained that the boring was actually made by Messrs. Legrand & Sutcliff, who supplied him with more complete particulars of the strata which were traversed. According to their account the depth of the boring was only 400 feet and the

depth of the pit at the time was only 56½ feet, consequently the total depth reached was only 456½ feet, not 526½. There is therefore a serious difference between the account furnished to me and that given by Messrs. Legrand & Sutcliff, but Mr. Reid does not mention the fact, so that readers of the memoir might imagine that he did not consider the discrepancy to be worthy of notice.

In reply to inquiry, however, Mr. Reid has informed me that he did not publish the account given him without trying to ascertain the facts on the spot; that he went to Heathfield and saw the manager of the potteries and the foreman who was in charge while the boring was being made. As a result he came to the conclusion that someone had confused the depth from the surface with the actual depth of the boring, and that the latter was only 400 feet deep from the floor of the pit, which was then only 56½ feet deep, but had subsequently been deepened to 70 feet.

On receipt of this information I felt it incumbent on me to make further inquiry in order to satisfy myself that this conclusion of Mr. Reid's was correct. Application to the Manager of Messrs. Candy and Co. did not produce any satisfactory result; it appears that the record possessed by the firm gives the figures which were communicated to me, and the Manager can only state that he has not been able to find any positive evidence to show that a mistake was made in constructing the tabular section.

On the other hand, Messrs. Legrand & Sutcliff, by whom the boring was actually made, are able to give more definite information. Asked if they could confirm the account printed in the memoir of the Geological Survey and if payment was received for only 400 feet of boring, their answer was in the affirmative to both questions. Consequently I am now satisfied that the actual depth attained by this boring was only 456½ feet from the surface of the ground, that the figures and particulars given me in 1908 were incorrect, and that the account based thereon and published in my paper on the "Depth and Succession of the Bovey Deposits" in 1909 is erroneous.[1]

It is desirable that this conclusion should be put on record, because if no explanation were made those who may hereafter take an interest in the matter would be faced with two inconsistent accounts of the boring, and might find it difficult to ascertain which was the correct one. The case is only one more instance of the curious errors which creep into the records of borings. One can only wish that it was obligatory on all those who have borings made to a depth of more than 100 feet to notify the fact to the Geological Survey Office, so that the results could be properly recorded at the time, and be preserved where they would be accessible to all geologists and engineers. Publishers are obliged by Act of Parliament to supply copies of all books to the British Museum, and it is really of greater public importance that the particulars of all such borings should be communicated to the Geological Survey Office.

[1] Since the above was written the Manager of Messrs. Candy & Co. has informed me that having looked up the charges for the boring he finds that they were for only 400 feet. He admits, therefore, that a mistake must have been made in compiling the account of the section preserved in their office.

VI.—Professor Walther's Erosion in the Desert considered.

By W. F. Hume, D.Sc., F.R.S.E., F.G.S.,
Director of the Geological Survey of Egypt.

IN the *Cairo Scientific Journal*[1] the first chapter of Professor Walther's new edition of *Das Gesetz der Wüstenbildung* was considered in some detail. His second chapter, "Die Abtragung in der Wüste" (pp. 111–218), is no less stimulating to thought and replete in observation. He opens this section of his work with a statement of the facts which point to great climatic stability in Egypt during historical times. Two of these are specially mentioned. First, the presence of a small sack of salt in a grave of the Eighteenth Dynasty, the analysis of which agreed absolutely with that of the salt at present obtained from the lakes of the Wadi Natrun. This occurrence, according to him, proves that the same salt mixtures were being formed at periods 3,500 years apart. A statement as to the nature of the resemblances which lead to so wide a conclusion would have been of interest. Secondly, attention is also called to the total absence of water in the Tombs of the Kings since they were first excavated, pointing to the underground water having stood for many thousands of years at more than 50 metres below present valley level.

No doubt these conditions indicate climatic similarity, but other arguments, such as the opening of routes across the desert in early times, have been adduced in favour of a less marked aridity than at present exists. The question is one calling for much wider treatment than has yet been given it, but it is as well to have every thoughtful observation recorded as material for further discussion. The uniform character of the Nile alluvium, and the great development of the longitudinal dunes in the Libyan desert, certainly point to very little climatic modification during the historical period.

A long section is devoted to the erosion of Egyptian monuments by sand-blast, and as it is illustrated by photographs from the neighbourhood of the Pyramids it is of considerable interest to those dwelling in this country. So also are the pages in which Professor Walther regards the destruction of many of the monuments in Karnak and elsewhere as due to weathering through temperature variations, and not, as is commonly assumed, to earthquakes. The Memnon statues, for instance, built as they are of Nubian Sandstone cemented by siliceous material, and based on the Nile alluvium, are not readily liable to fracture by earth-movements, while they have been subject for many centuries to the great variations of temperature (insolation) by day and by night. The musical notes of the Memnon, which lasted for some two hundred years, are regarded by Professor Walther as due to the wind traversing one of these fractured portions, the sounds ceasing as soon as the statues were walled in by Septimus Severus.

Section 14 deals with "Dry Weathering" (Trockene Verwitterung). Attention is called to the very important activity of evaporation in the desert areas, by which many solutions present in the upper portions of the crust are being continually drawn to the surface, and

[1] *Cairo Scientific Journal*, No. 77, vol. vii, pp. 32–41, February, 1913.

there evaporated with deposition of saline and other dissolved constituents.

These are practically 'desert evaporation effects', and in spite of his statement that by the use of the term 'dry' he does not mean absolute absence of water, the title of this part of the section is distinctly misleading, though applicable to features dealt with later in the chapter. Futterer has given the name 'exsudation' to these phenomena, which appears preferable. The effects of these activities are manifold and everywhere obvious, and those who desire a careful study of this question in its economic aspects will find valuable details in Mr. Lucas's Survey memoir on the *Disintegration of Building Stones*.

In considering the effects of these evaporating solutions, attention is called to what the author terms 'mass-movements' in the rocks. According to him (p. 124) there have been upward movements of materials in certain cases, and as an example he mentions one of the stones in a wall on the west side of the Great Pyramid which has 'squeezed out' some 8 centimetres beyond the regular line of blocks of which it forms a part. He also cites cases of smaller fragments found on the surface, obviously splintered from the parent foundations, and now separated from them by several metres of made ground. It would be interesting to have the views of archæologists as to these anti-gravitational movements suggested for pottery and other objects of human construction embedded in soft muds.

A small section is devoted to the very beautiful 'rippled limestones' often found on the surface in the Egyptian and Atacama deserts. These were regarded by Abel as being fragments lifted into the air during heavy wind-storms, rotated rapidly, and etched on all sides by streams of blown sand. The size of the blocks seems, however, to exclude any such explanation. One would be extremely sorry to face a sand-storm such as would move the fine specimens now in the Geological Museum of Cairo. Beadnell, who collected these and described them as 'vermicular', justly called attention to the fact that these structures only occur (at any rate as a rule) in a hard grey crystalline limestone, and he connected their origin with drifting sand. According to him they would appear to depend on the internal structure of the rock rather than on any external conditions, but may perhaps be partly due to the irregular paths taken by sand grains in motion. Professor Walther points out that they occur both on angular and rolled limestone fragments, and these of very varied size, excluding, as above stated, the idea of movement. Where the 'Rillensteine' or ripple-stones lie on a clayey basis the ripples are sharp and resemble the solution figures which are produced when limestones are etched with weak acid. Calcite veins in the pebbles are more completely dissolved, and leave sharply marked furrows with a breadth at the surface of 1 to 4 millimetres. Where, however, sand is spread over the desert floor, or the surfaces indicate previous sand action, the ripples are smoothed down and disappear on the lee side. In digging down they are found with well-emphasized markings to a depth of 10 to 20 centimetres; in large fragments Professor Walther noted that the continuous ripples beneath the surface were clearly marked, but above it were smoothed, rounded, and polished.

He concludes that the 'ripples' or 'vermicular' markings are produced in the soil and near the surface through the action of concentrated solutions rising to the ground-level. As they slowly move along the side of the limestone fragments they produce linear markings. The removal of the clayey material reveals the etched surfaces, which are gradually worn down by the sand, while new ripple-stones are uncovered as the clay is removed by wind from around them.

There is always an advantage in having some explanation given for any phenomenon, because it at once arouses the critical faculty in the majority of mankind, and this tends to progress. Like Professor Walther, I have sought for an explanation as a solution effect, in which dew or rain, concentrated solutions of contained salts, and a particular rock-structure resulted in these curious markings.

Professor Walther is naturally also impressed with the changes on rock masses themselves resulting from the movement of highly concentrated solutions through them. In this connexion reference is made to the remarkable grape-like aggregations which are formed when finely divided carbonate of lime, clay, and quartz sand are moistened and subsequently become bound together under the influence of the sun's heat. He next turns to a question which has aroused much interest, viz. the origin of the gypsum present in enormous thickness near the Red Sea and elsewhere. Attention is called to Professor Natterer's observation that the waters of the Red Sea penetrate for long distances into the rocks of the shore-line, and there produce metasomatic changes. It is rightly pointed out that these regions are like a huge retort, in which remarkable chemical changes may be proceeding on a vast scale. Professor Walther frankly adopts the view that the gypsum is not a primary deposit, but represents the wall of the Erythræan depression, formed originally of marine limestones, but subsequently altered to gypsum.

In this connexion he calls attention to the pseudomorphs in selenite of bivalves, gasteropods, and corals collected by Dunn on an island south of Berenice. Far from this being an isolated case, examples are available from many parts of Egypt. At Abu Mingar there is a very interesting stratum in which a very inflated bivalve (*Diplodonta*) is formed of glassy-looking selenite; at Jemsa a bed of small *Corbulæ* is entirely replaced in gypsum, and the change can also be observed taking place in a limestone bed on Little Jemsa. The surface layers of calcareous strata are frequently altered to powdery gypsum, and Wade has called attention to the metamorphosis of the large basin shell *Tridacna* into the same material.

Nor is this the only case of formation of sulphates. The Survey Chemical Laboratory has examined many specimens collected by the Geological Survey, the analysis of which show that sulphates of alumina and iron play a most important role in desert deposits.

The change of ordinary limestone to a true dolomite by the action of magnesian salts is equally impressive. Sea-water breaking through the open-work structure of projecting masses of coral show replacement of this kind to a marked degree. The rapidity of

chemical changes of this nature was illustrated in the Graving Dock at Alexandria. Certain curious coralloid-looking growths, formed along fissure-planes in the bottom of the dock, proved on examination in the Chemical Laboratory of the Survey Department to be compounds of magnesium and calcium carbonates, produced by the attack of the magnesium salts in the sea-water on the carbonate of lime in the concrete blocks.

On p. 128 et seq. the question of weathering under the influence of solutions rising to the surface is carried a stage further. By the crystallization of the salts fragments are split off the surface and, where exposed, are soon broken up and carried away. This is not, however, the case in cavities and wind-shaded spots. There the loosened plate-like portions attached to the parent rock, and, if they are hygroscopic, may contain sufficient water of solution still to be chemically active. This affords another explanation for the remarkable cavities developed in the granites of tropical regions, where their position is such as to exclude the direct action of wind-borne sand. It will require a chemical pronouncement to decide whether the contained salts in the weathered portions would be sufficient to produce the remarkable effects observed.

Professor Walther next considers the conditions which lead to fracture of rock masses, such as is commonly assumed to result from the influence of temperature variation. He illustrates the conditions observed by photographs of the 'melon' region of splintered flints in the Libyan Desert, and especially by some fine photographs of fractured granite and diorite blocks, the latter from the pass of Belowitak in the Ethiopian Hills. Here the diorite possessed most of the characteristic features of desert weathering. It has a deep brown surface film, the individual blocks have been fractured asunder into pieces whose former connexion is indisputable, the surfaces are breaking up into flakes arranged tangentially. The rocks have undergone no chemical alteration, but all around the foot of the huge boulders is a coarse gravel composed of small fragments of the rock, or where granite is present of small quartz and felspar grains.

Each of these characteristics, which combined are the true 'dry weathering', has its special method of origin, the most easy to explain being the tangential flaking, or desquamation (to use von Richthofen's term). When a boulder is warmed by day and cooled by night the effect of increase of volume due to the heating only extends to a small distance inward, the thickness of the surface affected depending on the nature of the rock. Gebel Kassala is given as an example of the remarkable smooth surface slopes covered with huge 'shells' separated from the parent mass and still only slightly attached to it, while around the base lie the shattered fragments of others loosened from their supports. Fig. 70, illustrating this feature, is somewhat disappointing. Plate xi in my Eastern Sinai memoir is a far more impressive example of these occurrences. Excellent illustrations are given of a fractured quartz grain and of a fracture mosaic on p. 61, while in studying this section the reader may turn back with advantage to figs. 25 and 26 for examples of 'pitted', 'flaking', and 'vertical' splitting.

The opinion is expressed that the best explanation of these phenomena has been given by Pechuel-Lösche, who ascribes them to the sudden cooling produced by a torrential rain falling upon highly heated surfaces. Attention is called to the intensity of physical change when rain at 20° C. or hail at 0° C. suddenly falls on rocks heated to 80° C. Numerous small cracks are produced due to cooling, subsequently often enlarged by temperature variations in blocks suitably exposed.

He also mentions the extraordinary cavernous weathering exhibited by rocks of heterogeneous composition and variety of mineral colouring, such as the granite (see fig. 73). The variously coloured constituents expand with varying rapidity under the solar influence, and also in cooling contract at different speeds. This constant interplay causes a loosening of the individual particles, so that it is very difficult to obtain a solid specimen of typical red granite or other igneous rock in the Red Sea Hills or Sinai. To this breakdown he ascribes the frequency of sand-slopes among the granitic hills, the wind sorting out the materials, the quartz remaining to form the dunes, while the mica is swept onward into protected places and the felspar rapidly breaks up into cleavage fragments.

(*To be concluded in our next Number.*)

REVIEWS.

I.—The Coal Resources of the World: an enquiry made upon the initiative of the Executive Committee of the Twelfth International Geological Congress, Canada, 1913, with the assistance of Geological Surveys and mining geologists of different countries. Edited by William McInnes, B.A., F.R.S.C., D. B. Dowling, B.A. Sc., F.R.S.C., and W. W. Leach, B.A. Sc., of the Geological Survey of Canada. 3 vols. Crown 4to; pp. 1266 + civ, with plates and illustrations in the text and accompanied by an atlas of maps. Toronto, Morang & Co.; London, Dulau & Co.; 1913. Price £5 5*s*.

IT is a truism that a deposit of iron-ore is of no value if there is no supply of coal. This comprehensive and valuable work, chiefly written in English, therefore forms a fitting sequel to the monograph on the iron-ore resources of the world issued by the Eleventh International Congress in 1910. The present volumes, in a series of articles written by experienced geologists and mining engineers, afford valuable information about all the known coal-bearing regions of the world. In the case only of Greenland, Peru, and Brazil has it been necessary to compile from published literature, so that the monograph affords the latest and most authoritative pronouncement on the "coal resources of the world" and replaces all previous literature on the subject.

To review adequately such a large amount of information is here impossible; a brief résumé of the general scope of the work, with

mention of a few of the more interesting and striking features, is all that can be attempted.

Tables giving the Actual, Probable, and Possible Resources for the individual countries and districts naturally occupy a prominent place, but generally they are accompanied by a geological description, amounting in some cases to a thesis on the subject, and containing much new matter of great interest to the geologist. To ensure uniformity the different types of coal are entered in several classes, which correspond roughly to (A) anthracite and dry coals, (B and C) bituminous coals, (D) sub-bituminous coals, brown coals, and lignite.

The tables of production show at a glance the scale on which individual countries are at present engaged in the industry, the United States easily heading the list, seconded by Great Britain, but followed very closely by Germany. In all these the annual production reaches hundreds of millions of tons, while none of the remaining countries reach an output of forty millions of tons.

A useful summary and digest of the Reports is given, a task which must have seriously taxed the editors, as some of the contributions did not reach them until the middle of May, 1913. For this reason "the latest reports, being longer than anticipated, had to be hurriedly condensed, and many illustrations and maps not adapted for direct reproduction in the form in which they were received had to be omitted". It would be obviously unfair, therefore, to criticize the character of the text-illustrations and of the plates given in the atlas, but a great divergence in colouring and execution is noticeable. The omissions, however, are not serious.

The coal resources of the world are given as 7,397,553 millions of metric tons, and the annual production as 1,143·38 million tons. A worldwide shortage of fuel evidently lies a long way off, though a considerable reduction in this colossal amount of coal must be allowed for loss in mining, for seams not at present mineable, and, what is more important, for seams mineable but not at a profit. Individual estimates also differ so enormously that some are openly little more than guesswork.

The world's supply is at present largely drawn from the later Palæozoic formations, but it is well to be reminded that equally rich and valuable seams occur in the Mesozoic and Tertiary formations, both in the Old World and in the New.

Taking the separate countries in the order in which they are dealt with in the volumes;—

The account of Oceania is given in much detail, and includes the new coal-fields of Antarctica.

In Asia, besides accounts of the lesser coal-fields, we have the latest information about Japan and China. The latter, true to tradition, has mined coal for several thousands of years, but so slowly does she advance that out of 38,765,000,000 tons of probable, in addition to 'enormous' possible reserves, she extracts, mostly due to foreign enterprise, only 18 million tons per annum. It is evident that many geological problems still await solution, as the following extract (vol. i, p. 210) will show: "In Ssŭ-ch'uan-shêng, Kuei-chow-shêng,

and Yün-nan-shêng, the basement complex of the region consists of phyllite, sandstone, and limestone, considered to represent the Devonian and Silurian. The lower part of the thick limestone which overlies the formation is of Devonian age, while the upper intercalates shale, sandstone, and quartzite with coal-seams, and represents the Carboniferous and Permo-Carboniferous. Another heavy limestone formation, with red shale in the middle and diabase sheet in the lower part, rests on it, and also contains coal-seams. It is the Permo-Trias. Most of the coal-seams in Kuei-chow-shêng and Yün-nan-shêng are interbedded in these two formations." Truly a Chinese puzzle.

Japan's contribution is a memoir in itself, well illustrated by maps and diagrams in the text, and by several artistically coloured and delicately outlined maps in the atlas. The statement (vol. i, p. 296), coming from one in a position to judge, that Japan will satisfy the demand for coal in the circum-Pacific country for many hundreds of years, particularly arrests attention.

The chief African coal-fields, as is well known, occur in the south, and the information supplied about the other still imperfectly known coal-bearing districts in Central Africa shows that the continent is not over abundantly supplied with coal. Northern Africa, except parts of the Nigerian Protectorate, appears to be almost destitute of coal other than patches of lignite.

The account of the great coal-fields of Canada, illustrated by eight maps in the atlas and by eight figures in the text, affords a useful summary of an important and rapidly growing industry. In the far north, as well as in other northern regions, deposits of coal are widely distributed.

A map in the atlas, showing the distribution of the coals according to class, in conjunction with six pages of tabular matter in the text, brings prominently into view the vast resources of the United States. Of the coal supplies of South America the available information is evidently still meagre and uncertain.

The reports by the leading authorities on the European coal-fields occupy 552 pages of printed matter, abundantly illustrated by maps and diagrams and accompanied by no less than twenty maps in the atlas.

In Holland a great thickness of unproductive cover shows how much of its coal lies hopelessly beyond reach.

In Great Britain, while an area of 206 square miles in the concealed coal-field of Kent is included for the first time among the estimates for this country, 760 square miles is substituted for one of 2,550 square miles for the unproved area in Yorkshire and Nottinghamshire. This reduction has been made in conformity with explorations in the valley of the Trent between Nottingham and the Humber, completed since the Report of the Commission in 1905, and of which the results have been published recently (1913) in an official memoir.

This great change in the estimated resources of one of the most highly developed coal-fields in the world shows that it is necessary to exercise great caution in accepting too literally the figures given for imperfectly explored regions.

II.—Igneous Rocks. Vol. II. By J. P. Iddings. 8vo; pp. xi, 685. New York: Wiley and Sons, 1913. Price 25*s*.

WHEN it was announced a few years ago that a group of distinguished American petrologists had decided that the time was come to reform the classification and nomenclature of igneous rocks most students of petrology looked forward with interest to the appearance of a textbook showing how the new classification actually worked out in practice. The most severe and final test of such a proposal would thus be furnished. Professor Iddings' textbook, however, does not meet this demand. It runs very much on the old lines, the 'qualitative' system, so heartily condemned, serving as the basis on which the rock groups are arranged, while the 'quantitative' classification appears only in short appendices to the chapters, printed in small type, and very interesting, but far from complete.

This treatment makes the book much more valuable to the student preparing for examination. All the well-known varieties of rocks are described under six divisions according to their component minerals, from those which consist mainly of quartz, to the ultra-basic rocks such as the pyroxenites and peridotites. Each group is subdivided into (*a*) phanerites (coarsely crystalline), and (*b*) aphanites (finely crystalline or partly glassy). Chemical analyses are given mostly in separate tables. The new American names appear seldom except in short discussions of the grouped analyses, and the 'mode' instead of the 'norm' is the dominant factor in the classification.

One merit of this textbook is that it is well abreast of the times, and the new rock-species recently described from districts such as the Urals, Finland, and Western North America obtain recognition, and at any rate a brief definition. The author occasionally, though all too seldom, gives us a criticism of the validity of the older names such as theralite and essexite (pp. 231 and 247). The first part of this volume, containing the description of the rocks, is only 330 pages, much too short for adequate treatment of the subject, and is hardly sufficient for more than a definition of the established rock-names. It reads very much like a catalogue, and the 'microscopic physiography' of the different rocks receives little notice. Within its limits, however, the book is excellent, and should be in the hands of all senior students of petrology.

The second part of the book describes the occurrence or rather the distribution of igneous rocks. We have read it with great interest, as it provides a valuable summary of what is known regarding the igneous rocks of all parts of the world. They are grouped under geographical provinces such as North America, South America, and Europe, and an attempt is made to define also the geological age of the rocks described. Moreover, fairly full references are given to the literature, and a useful set of maps is provided to show where the rocks are situated. Professor Iddings is sceptical about the value of 'petrographical provinces', and he lays down criteria which, in our opinion, are unnecessarily rigid (p. 346). It is sufficient for the meantime if we can recognize that the rocks of certain districts belonging to a certain epoch have well-marked characters which

distinguish them from, or relate them to, those of other districts or epochs. The problem is a very large one and does not admit of very rigid treatment in the present state of our knowledge or ignorance. It seems to us that no more convincing argument in favour of the views of Judd, Harker, Prior, and Becke, has ever been brought forward than Professor Iddings' calm and impartial summary of the facts. The contrast furnished by the volcanic rocks of Africa, mainly 'alkali-rocks', with a few andesites in the north-west part of the continent, with the andesitic volcanoes of Japan, with a few centres of alkali rocks on the western side, is as striking as the difference between the broken plateau of Africa and the ridge-folds of Japan. It is true there are many exceptions and anomalies, but these do not affect the main issue. They show merely that there is much work to be done in this field, many types and sub-types still to be defined and established, and many disturbing factors to be taken into account. It lends a new interest to petrology which seemed about to lose itself in a wilderness of descriptive material, endlessly varied, but leading to few wide generalizations. The application of exact methods to the experimental synthesis of rocks and minerals and the study of magmas in relation to the physical history of their province are the most notable advances of the science of petrology in recent years.

The second part of this volume, accordingly, is of the greatest importance to students of petrology. Professor Iddings has spared no labour to become acquainted with the facts at first hand, and he marshals them in order and places them clearly before us. Many small inaccuracies might be pointed out in the chapter on British rocks, but these are mainly due to the imperfection of the descriptions given by the older writers on the subject. The volume fills an important gap in the list of books required by the student of rocks for his daily work.

J. S. F.

III.—Mountains: their Origin, Growth, and Decay. By James Geikie, LL.D., D.C.L., F.R.S., etc., Murchison Professor of Geology and Mineralogy in the University of Edinburgh. 8vo; pp. xix, 313, with 81 plates and 57 text-illustrations. Edinburgh: Oliver & Boyd. Price 12*s.* 6*d.* net.

SINCE the publication in 1886 of T. Mellard Reade's *Origin of Mountain Ranges* there has not been issued in this country any work dealing exclusively with this subject from a worldwide point of view, although of course a mine of information is to be found in the monumental work of Suess, *Das Antlitz der Erde* (English translation, 1904–9). Of more recent works those on *The Building of the Alps* by Professor Bonney, and *Earth Features and their Meaning* by Professor W. H. Hobbs, both published in 1912, have been noticed in the Geological Magazine. The subject in those two volumes is dealt with in a manner less severely scientific than that of Mellard Reade, and this is the case with the handsome and profusely illustrated volume before us. As remarked by Professor Geikie, all that he has attempted "is such a comprehensive sketch as may be helpful to readers not specially versed in Geology, who desire a fuller

statement of the subject than is usually presented in geographical text-books". Technical terms have been avoided as far as possible, but a glossary is given in the appendix. The type is bold and clear, and there are few footnotes.

The author does indeed take a very comprehensive view of his subject. Professor Hobbs, in defining a mountain, remarked that the word is "applied to a feature of the earth and not merely to an elevated tract", as in the case of high plains; "their summits need not be at great heights above the sea, but it is essential that they project above the average level of the surrounding country by at least a quarter of a mile." To this or any other definition no strict adherence is made in geographical works, "elevations of the same height being called hills in one locality and mountains in another." The Malvern Hills, for instance, form a true mountain range in point of structure, and, as Professor Geikie observes, even diminutive hills must sometimes be put "into the same class with the loftiest mountains of upheaval". We find therefore that, in elucidation of his subject, the author more or less briefly describes various mounds and low hills of glacial detritus or wind-borne sand. His general grouping of hills and mountains is: I. Original or Tectonic; II. Subsequent or Relict mountains.

The Original or Tectonic mountains are classed as (1) those due to Accumulation, and (2) those due to Deformation. We are brought first to consider the eminences due to volcanic accumulations, and the subject is illustrated by many text-figures and fine plates. Here it may be mentioned that the term 'cone-in-cone' is applied to small and younger cones within a more extensive eroded crater-ring or caldera; but the term is more usually applied to nail-head spar or fibrous calcite, and to peculiar concretionary and crystalline structures seen in coal. Geyser sinter-mounds, moraines and other glacial features, and sand-dunes now come in for attention, many of these being of less altitude than the artificial Silbury Hill or the 'tips' from mine-works.

Passing on to the Deformation mountains, we come to the main portion of the subject, one which concerns "nearly all the more prominent ranges and chains of the globe". Three types are recognized, namely, Folded, Dislocation, and Laccolith mountains. The author's object is to give particulars of the geological structure, discussing theories of uplift and the origin of the features, without dwelling much on the scenery. This last-named topic is, however, well illustrated by the beautiful plates, produced mostly from photographs taken for the Scottish branch of the Geological Survey.

The various types of folding and dislocation are clearly explained, with the aid of diagrams and sections, as well as by photographic views of rock-structures seen in hand-specimens and in exposed rock-masses. The author observes that "To-day the prevalent belief is that deformation of the crust has probably as a rule taken place slowly and gradually, and that erosion and denudation have necessarily accompanied the elevation of mountains, so that throughout the whole period of their growth or upheaval they have been subject to continual degradation". This is no doubt true enough,

but the effects of earth-movements on the shapes of valleys, as indicated by Professor J. W. Gregory in his work on fiords (see GEOL. MAG., December, 1913), has not always been sufficiently considered. How greatly disturbances have influenced the physical features is shown in the present volume in some of the sections of the Vosges, Alps, Western Jura, and Uinta Mountains.

There are grand views of mountain peaks and others showing the influence of weathering agents on different rocks, as in the Dolomite mountains; the influence of joints, columnar, tabular, etc.; of sills and laccoliths, batholiths or bosses, as in the Skye plateaus and mountains, the latter generally known as the Cuillin and Red *Hills*.

One chapter is devoted to an account of the leading geological phenomena of the Pacific Ocean and its coast-lands, and the author expresses his opinion that "Although it is not possible to demonstrate that the Pacific Ocean is of primeval antiquity, yet all the phenomena seem to favour that conclusion, and to negative the idea of a great Pacific continent such as the geosynclinal theory desiderates".

The Subsequent or Relict mountains include those carved out of plateaus of accumulation, such as the basalt plateaus of the Inner Hebrides, the heights of Saxon Switzerland, the tabular mountains of North African deserts, the Buttes of Wyoming, and the Bad Lands of Nebraska, as well as other escarpment heights and the features connected with cañons. It is admitted that some laccolith heights and many volcanic 'necks' must be regarded as Relict mountains, but, as the author observes, it is usually difficult, when dealing with Nature, to draw hard and fast lines.

IV.—THE EVOLUTION OF THE CRETACEOUS ASTEROIDEA. By W. K. SPENCER, B.A., F.G.S. Phil. Trans. Roy. Soc., ser. B, vol. 204, No. 306, pp. 99–177, pls. 10–16, 1913.

THE work of Mr. W. K. Spencer on the Cretaceous Asteroidea, published during the last few years in the volumes of the Palæontographical Society, has been done chiefly from the systematic point of view. Much light has been thrown on the subject by his philosophic treatment in the present paper of the evolution of the group. A clear and useful summary of the aims of the essay serves as an introduction to the author's results, which are arranged under three headings, dealing respectively with the description of the 'species series', stratigraphical conclusions, and variation and evolution. Eight new genera and one new subgenus are established, and the classification adopted is that of Perrier.

The Cretaceous rocks not only of England but also of many important Continental districts have been considered, and from the stratigraphical point of view the results are satisfactory. The author finds that the Asteroid fauna could be used as a basis of horizonal classification, and that isolated ossicles are of value for zonal purposes. In the Upper Chalk of England the distribution of the Asteroids shows the zoological break at the top of the lower third of the *coranguinum* zone that was observed by Dr. Rowe in the case of the Echinoids. For this reason, as Mr. Spencer thinks, it would be

convenient to adopt the suggestion of Messrs. Brydone and Griffith to include this lower part of the *coranguinum* chalk in the zone below. As regards the Upper Chalk, too, the author was led independently to recognize the existence of two separate stages, which were subsequently established by Mr. Jukes-Browne (Geol. Mag., Dec. V, Vol. IX, pp. 304–13, 360–72). The paper contains interesting observations with respect to the depth at which the various deposits were laid down, and the remarks on the Starfish fauna of the *cuvieri* zone at Branscombe (Devon) bear out the views of Messrs. Jukes-Browne and Rowe that a Greensand ridge existed in the neighbourhood of the Hooken, as is shown also by Sherborn.

Measurements of numerous ossicles have been taken with a view to discussing variation. It is shown that isolated supero-marginal ossicles can be taken as trustworthy indications as to the size and relative height of the individual. It is probable also that a high ossicle may represent some physiological advantage to the starfish, since the marginalia border the visceral cavity, and therefore an increase in height would allow greater space for the digestive organs and the gonads. In considering variations in a lineage Mr. Spencer adopts as a unit the tangent of height to length (of a supero-marginal ossicle), which he calls the ossicular angle, and the results are expressed graphically. The continuousness of variation shown to exist would render zonal work difficult but for the coexistence of other independently variable characters. Periodic elaboration, to which attention has been drawn in other groups by Bernard, Buckman, and Lang, is also traced. All races pass through parallel stages, and some variations must be regarded as predetermined; of some, in fact, the course could be predicted.

Apart, however, from its theoretical interest the paper has great practical value in that the collector can determine with a degree of certainty the isolated ossicles that are commonly found. Considering the unpromising nature of the material, Mr. Spencer's results are extremely encouraging to the palæontologist.

V.—United States Geological Surveys.

1. Coal Fields of Grand Mesa and the West Elk Mountains, Colorado. By Willis T. Lee. pp. 237, with 21 plates and 37 figures. Bulletin 510. 1912.

THIS bulletin contains a description of all the mines in the various districts and a discussion of the general geology and stratigraphy, illustrated by a geological map on the scale of 2 miles to the inch. The section on the quality of the coal contains over eighty analyses of samples.

The coal-fields of this area occur on the southern edge of a great basin in Western Colorado and Eastern Utah. The lowest beds exposed are shales and sandstones of the Gunnison formation, regarded as Jurassic in age. An unconformity separates these beds from an Upper Cretaceous series, which attains a thickness of some 6,000 feet and includes all the coal-bearing beds. The base of this series is formed by the Dakota Sandstone, which is overlain by the Mancos shale, containing coal of poor quality near the base, and fossils

belonging to the fauna of the Montana group. The Mancos shale corresponds to the Montana and Colorado formations of earlier writers, Eldridge's Fox Hill division being represented by a transitional zone between the Mancos shale and the overlying Rollins Sandstone. The rest of the Upper Cretaceous rocks, about 2,900 feet, are represented by: (1) the Rollins Sandstone, containing *Halymenites major* and *Inoceramus*; (2) the Bowie shale, coal-bearing throughout, with marine and brackish-water shells; (3) the Paonia shale, also coal-bearing but characterized by abundant plant-remains and freshwater shells; (4) an undifferentiated thickness (2,000 feet) of sandstones and shales with plant-remains and freshwater shells, but containing only a little poor coal. The Bowie shale is absent in the central part of the Grand Mesa field, and elsewhere in the area it is separated from the Paonia shale by an unconformity.

The lower part of these Cretaceous beds was classed by the geologists of the Hayden Survey of 1881 as Fox Hills Sandstone, the upper part as Laramie formation: the invertebrate fauna, however, indicates that they may now be correlated with the upper part of the Mesaverde formation of South-Western and North-Western Colorado. The evidence of the plant-remains from the freshwater beds above the unconformity is less conclusive, and accordingly Mr. F. H. Knowlton's notes on the flora are given in detail. He concludes that the Paonia shale is certainly of post-Montana age and that it may prove to be Laramie or even still younger.

The Cretaceous rocks are overlain unconformably by the Ohio Creek conglomerate which Eldridge regarded as Cretaceous but which is now shown to be Tertiary. Another unconformity separates this from the Wasatch and Green River formations, a series of unfossiliferous sandstones and shales, probably Eocene.

The igneous rocks of the area were described by Whitman Cross in 1894. They comprise great laccoliths of quartz-monzonite porphyry of Tertiary age, basalt flows, possibly early Pleistocene, and a great development of andesitic breccias.

The burning of coal at the outcrop is the subject of an interesting note. This is less general on northern soil-clad slopes than on the dry southern faces of the hills. No evidence was found in favour of the theory of spontaneous ignition, and it is thought that the burning of the coal is due to forest fires.

In many places no coal appears at the outcrop, and quite the most striking point in the book is the evidence of the fossils on the nature of the buried coal which a prospector may expect to find at a given locality. It is pointed out that the high-grade bituminous coals are associated with the marine Bowie shale, characterized by *Halymenites major*, *Inoceramus barabini*, *I. sagensis*, *Cardium speciosum*, and *Ostrea subtrigonalis*; on the other hand, low-grade bituminous or sub-bituminous coals are found in the freshwater Paonia shale containing freshwater shells and plant remains. Seven splendid plates depict the most characteristic and easily recognizable fossils from the coal-bearing beds. This forms only one of many instances in which the United States Geological Survey have demonstrated the very close relation of purely scientific to economic geology.

2. Geology of Alaska.—We have received six bulletins relating to this territory, all published in 1913. No. 526 is on the "Coastal Glaciers of Prince William Sound and Kenai Peninsula", by Messrs. U. S. Grant and D. F. Higgins. This is well illustrated by maps and pictorial views, and "is intended to supply some definite information regarding the present positions and fronts of the glaciers, and the more evident facts of their fluctuations", with the desire also of attracting attention "to some of the most magnificent American scenery that is now accessible to the tourist and nature lover".

Five other bulletins contain descriptions of the geology, and especially of the placer deposits, of various parts of Alaska, and they will be invaluable as guides to prospectors and to further mining enterprises. No. 532, on "The Koyukuk–Chandalar Region", by Mr. A. G. Maddren, deals with a portion of the Yukon river-flats and of its tributary the Koyukuk. No. 533 is on the "Geology of the Nome and Grand Central Quadrangles", by Mr. F. H. Moffit, who describes an area in the southern part of the Seward Peninsula. It is remarked that "Bonanza mining in the Nome region, which has produced over $50,000,000 worth of gold, is now nearly a thing of the past", but the record is "of one of the richest placer camps of Alaska". Nevertheless the prospects of further profit are by no means discouraging; there are still "large bodies of auriferous gravels, many of which can be profitably exploited", while "the field is well worthy of careful prospecting for vein deposits". Although gold only has been mined with profit, small quantities of lode and placer tin have been obtained, and the occurrence also is noted of silver, lead, tin, bismuth, antimony, tungsten, copper, and mercury, in bed-rock and gravel deposits. No. 535 contains "A Geologic Reconnaissance of a Part of the Rampart Quadrangle", by Mr. Henry M. Eakin. This area lies along the Yukon River above Tanana town, and extends to the tributary valley of the Tanana River at Hot Springs. Gold occurs in the modern stream deposits and in the older terrace or bench gravels, but no other mineral has proved to be of economic importance. No. 525 is a "Geologic Reconnaissance of the Fairbanks Quadrangle", by Mr. L. M. Prindle, with assistance from Mr. F. J. Katz and Mr. Philip S. Smith, and is the most elaborate of the reports before us. The area adjoins that of the Rampart Quadrangle, extending higher along the course of the Tanana River. The report indicates that the placer-gold reserves are still very large, but that a great expansion of the industry in this field "can be brought about only by lessening the operating costs through improved means of communication". There are favourable prospects also for lode-mining, though at present the alluvial deposits have furnished practically all the gold. "Silver occurs as an impurity in the placer gold." It is remarked that most of the alluvial deposits are frozen throughout the year. No. 534 contains an account of "The Yenta District", by Mr. Stephen R. Capps. The Yenta River is a tributary of the Susitna, which flows into Cook Inlet on the southern side of Alaska. The Alaska Mountains lie to the north-west, and it is remarked that "the

assignment to the Tertiary instead of to the Quaternary of the heavy gravels which mantle the foothills on both sides of the Alaska Range will necessitate considerable change in the published interpretations of the physiographic history of Central Alaska". The stream-erosion in Tertiary times concentrated some gold in the old river beds, but none in the Eocene lignite-bearing deposits which underlie the Tertiary gravels. There are no valuable auriferous lodes in the region, the placer gold alone proving of economic importance.

These reports are well illustrated by geologic and topographic maps, by views of scenery, rock-structure, and mining works. They contain descriptions of the physical features, climate, drainage, and water supply, of the animal and vegetable life, including the distribution of timber, with remarks on the means of communication (transport and supplies).

The lode-deposits are developed in the metamorphic rocks, with which are associated intrusive (mostly unaltered) granites and diorites that are possibly of Jurassic age. It is considered that these intrusive masses "have influenced the gold-bearing mineralization". The schistose rocks are grouped as Pre-Ordovician?; and in some areas there are also Ordovician, Silurian, Devonian, Carboniferous, and Cretaceous formations. The Tertiary lignite beds appear to be of little value except as a source of local fuel.

Much gold in the placer deposits has been reconcentrated from the Tertiary gravels, and some from Glacial deposits. Gold worked with profit in the gulches has been derived from the weathered vein-material of the bed-rock, and the deposits are termed residual placers, most of the material being not far removed from the parent source. The chief sources of the gold are in the lower-lying alluvial gravels. In the deeper deposits shafts have been sunk 200 to 300 feet, and where the deposits are solidly frozen steam is used to thaw them. In the higher bench placers gold is generally present and is locally sufficiently rich to be mined with profit. In the Nome area of Seward Peninsula there is much coastal-plain or tundra gravel, with beach placers, some of which are buried beneath the coastal-plain gravel, while others belong to the present beach: these in places are rich in gold. The gravel-plain placers "are small, and although one or two have yielded considerable gold, no very rich ones have yet been found" in the area. It is remarked that dredging promises to play an important part in the future development of the Nome district.

3. Geology of Idaho.—Bulletin No. 528 (1913) is on the "Geology and Ore Deposits of Lemhi County, Idaho", by Mr. Joseph B. Umpleby. The geological map shows the area, which is in the east-central part of the State, to be composed of Archæan gneiss; Algonkian quartzites, schists, and slates; Palæozoic (not separated), including Cambrian quartzite, Ordovician, Silurian (?), Devonian, and Carboniferous dolomites and limestones. There occur also Cretaceous or Tertiary quartz-diorite and granite, Tertiary lavas (rhyolite, andesite, etc.) and lake-beds, and glacial drift. The ore deposits include gold placers and lodes, lead-silver veins and tabular replacements, copper-bearing gold-veins, cobalt-nickel deposits, and tungsten-bearing veins.

The most important and older gold-veins are of late Cretaceous or early Eocene age, and appear to be genetically related to the great granitic intrusion. The younger gold-veins are enclosed in eruptive rocks, principally rhyolites.

VI.—Indo-China.

YET another large area of the unknown geological world has been explored by our friends and neighbours, whose labours are being made known in the Mémoires du Service géologique de l'Indo-chine. Of these beautiful publications we have received vol. i (fasc. i), *Étude géologique du Yun-Nan Oriental*, by J. Deprat and H. Mansuy, 4to, pp. 370, and nineteen exquisite plates of views and one of rock-sections, with accompanying atlas of 178 sections and many maps. Fasc. ii, by H. Mansuy, deals with the palæontology (Cambrian to Trias, Tertiary Lignite and Quaternary), and contains twenty-five excellent plates by Mémin of Arcueil (Seine); fasc. iii, by J. Deprat, is *Étude des Fusulinidés de Chine et d'Indochine et classification du Calcaires à Fusulines*; and fasc. iv treats of Laos and Tonkin in the following papers: "Géologie des environs de Luang-Prabang"; "Mission Zeil dans le Laos septentrional, résultats paléontologiques"; and "Contribution à la géologie du Tonkin, Paléontologie", all by H. Mansuy; the last illustrated by a series of similarly beautiful plates.

All these works seem to have been printed in Hanoi-Haiphong and published in 1912, and it gives us peculiar satisfaction to call the attention of the specialist to so rich a series of reference memoirs on Far Eastern Asiatic fossils.

VII.—Natural Sources of Energy. By A. H. Gibson, D.Sc., Professor of Engineering in the University of St. Andrews, at University College, Dundee. 8vo; pp. viii, 131, with 17 illustrations. Cambridge: at the University Press, 1913. Price 1*s.* net.

IN this little volume questions of general and worldwide interest are discussed, some of them having a direct bearing on matters of economic geology. The depletion of fossil fuels is in the first place considered, and reference is made to the probable life of British coal-fields, the lowest estimate being 175 years. Taking the most recent available estimates for the world, the entire supply is reckoned to be about 4,000,000 million tons. These immense quantities of coal, at the present rate of consumption, and "allowing for 33 per cent of wastage, would last some 2,500 years; whereas should the consumption keep on increasing at the same arithmetical rate as during the past five years they would be exhausted within 350 years".

With regard to oil fuel, while it is held by some authorities that "the manufacture of oil in Nature's laboratory" is still in progress through "the action of water vapour under high pressures upon various metallic carbides", yet it is considered that depletion would

be more rapid than the manufacture. Indeed, the author expresses the opinion that "the oil-bearing strata will be exhausted long before our coal-fields".

After considering the questions relating to natural gas and peat, the author turns attention to other sources of energy, to radium, to the radiant heat from the sun, the heat energy stored in the earth, that to be obtained from certain vegetable oils, timber, and alcohol, and finally to the energy of rivers, waterfalls, tides, waves, and winds. In his concluding chapter he remarks that "to our present knowledge, even when the fossil fuels are exhausted, ample supplies of energy, renewable year by year, will remain for all the conceivable activities of the human race". Nevertheless, with regard to Britain, he considers that "the prospects of maintaining our present supremacy as an industrial community in competition with other regions more favoured by nature, are remote", and the probability is that "the coming ages will see a gradual drift of the industrial centre of gravity of the world towards warmer climes where, at all events, the necessity for artificial heating for domestic purposes will be largely non-existent".

VIII.—The Fertility of the Soil. By Edward J. Russell, D.Sc., Director of the Rothamsted Experiment Station. 8vo; pp. viii, 128, with 9 plates. Cambridge: at the University Press, 1913. Price 1*s.* net.

THERE is no doubt that interest in the scientific aspects of agriculture is largely on the increase among those engaged in the cultivation of the land, and the little work before us is admirably adapted to stimulate that interest. From a geological point of view, however, there is little that calls for remark; there are brief accounts of the general characters and origin of soils, but the work is mainly occupied by a description of how plant food is made, of the chemical, physical, and organic influences at work in the soil, and of the methods of increasing fertility. The volume is clearly written and contains interesting accounts of agricultural operations in olden times, of drainage, reclamation, and manures; and there is a view of the chalking of land in Hertfordshire, the material being still obtained in places by sinking a shaft down to the Chalk formation, where it is covered by clay-with-flints and drift deposits.

IX.—Prehistoric Society of East Anglia.—The third part of the Proceedings of this Society (vol. i, 1913) is a volume of 138 pages, with more than 40 plates, and it contains 19 articles. Among these are one on a tumulus on Achill Island, another on pygmy implements from Cornwall, and a third on stone implements from Western Australia. The policy of publishing papers dealing with regions outside East Anglia may be questioned, as the topics would be more appropriate for a local Archæological Society. The subject of patination is discussed by the President, Dr. W. Allen Sturge, and illustrated by plates, in duplicate, showing patinated and unpatinated sides of implements. Mr. J. Reid Moir describes flint

implements from the Middle Glacial gravel and Chalky Boulder-clay of Suffolk; and Dr. Marie Stopes gives an illustrated account of the Red Crag shell portrait (see GEOL. MAG., 1912, pp. 285, 334). Among other articles is one on "The Problem of the Eoliths", by Mr. F. N. Haward, who thinks that "very few are humanly chipped".

X.—NORFOLK AND NORWICH NATURALISTS' SOCIETY.

AN interesting and instructive article on "The Topography and Vegetation of the National Trust Reserve known as Blakeney Point, Norfolk", by Professor F. W. Oliver, F.R.S., and Dr. E. J. Salisbury, F.L.S., has been published in the Transactions of this society (vol. ix, pt. iv, 1913). The Topography, by Professor Oliver, is of considerable geological interest, as it deals with the changes which have affected the coast. This comprises a shingle spit which leaves the shore near Weybourne, and extends about eight miles seaward slightly N. of W. On the landward side is the tidal inlet known as Blakeney Harbour, which at Cley receives the waters of the River Glaven. The area includes Blown Sand, unreclaimed salt marshes (saltings), and some reclaimed tracts, together with much bare mud; the National Trust Reserve comprises 3½ miles of the shingle spit from the Headland, and a strip of saltings abutting on the reclaimed marshes between Blakeney and Cley. It is remarkable that twenty-five small lateral shingle banks extend from the lee side of the main spit, and some of these known as 'Marams' are considered by Dr. Salisbury to possibly indicate the former extent of sand dunes, although the Marram grass (*Psamma*) is not now conspicuous. The marshward flow of the shingle is arrested to some extent by *Suæda fruticosa* and other plants. The distribution of the plants is fully dealt with by Dr. Salisbury, and the subject generally is well illustrated by maps and photographic views.

XI.—BRIEF NOTICES.

1. THE PALEOLITHIC IMPLEMENTS OF KANSAS.—A work entitled *The Weathering of Aboriginal Stone Artifacts*.—No. 1: "A consideration of the Paleoliths of Kansas," by Mr. N. H. Winchell, has been issued by the Minnesota Historical Society (8vo, cloth, St. Paul, pp. 186, illustrated by twenty figures and nineteen half-tone plates, 1913). In this volume the author applies the term Paleolithic "to any people, and their artifacts, which antedated the Kansan Glacial epoch. Early Neolithic includes the time elapsed between the Kansan and the Wisconsin Glacial epochs, and Neolithic applies to people who have existed in Kansas since the Wisconsin". Paleolithic types of implements were, however, found to continue into Neolithic times. The characters and patination of various implements are described and illustrated by the text-figures and plates.

2. YORKSHIRE CHALK FOSSILS.—"The Chalk Fossils in the Hull Museum" form the subject of an article by Mr. George Sheppard (Trans. Hull Scient. and Field Nat. Club, iv, 1913). A useful list is given of the species, a few of which are figured in two plates.

3. North of England Bibliography.—Mr. Thomas Sheppard continues his helpful list of "Papers and Records relating to the Geology and Palæontology of the North of England", those for 1912, Yorkshire excepted, being printed in the *Naturalist* for July last. It is announced that the Yorkshire items will be included in a memorial volume to the late C. Fox Strangways, that will shortly be published by the Yorkshire Geological Society.

4. Coal-fields of India.—In vol. xli of the Memoirs of the Geological Survey of India (1913), the work on Coal-fields, by V. Ball, has been entirely revised and largely rewritten by Mr. R. R. Simpson. He gives a practical account of the subject, illustrated by views of colliery works and machinery, by maps of the Raniganj and Jharia Coal-fields, and a more general map of the Central Provinces and districts further east, including Burma. There is also a useful bibliography.

5. Water-supply Papers, Nos. 305, 307, and 308 (1913), continue the records of "Surface Water Supply of the United States", and give particulars relating to Hudson Bay and Upper Mississippi River, Lower Mississippi River Basin, and Western Gulf of Mexico. No. 318 (1913) is on the "Water Resources of Hawaii", by Messrs. W. F. Martin and C. H. Pierce. Maps are given of the drainage of Hawaii and associated islands; there are particulars of gaugings, rainfall, etc.; and views of scenery, irrigation-works, etc.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

1. *November* 19, 1913.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

No papers were read, but in response to the invitation issued on November 5 eighteen or more exhibits were made of implements and reputed implements of Palæolithic and earlier age, and of flints showing various types of fracture.

The President, in opening the proceedings, said that the subject which had come before the Society for consideration was partly of anthropological interest, but fell also within the limits of geology. For the exhibits included specimens of flints from strata ranging in age so far back as the base of the Crag; and the determination of the age of the strata was clearly a matter for geological investigation.

The specimens exhibited included some for which evidence of human workmanship was claimed with much confidence, but without having obtained universal acceptance. There were also shown series of flints illustrating the manifold forms of fracture which are attributable to natural causes. A comparison of these with the reputedly artificial forms could not fail to be instructive.

A large number of flints, for which a human origin was claimed, had been found lying on the surface or embedded in the soil. These were chiefly of anthropological interest.

He considered that there were four lines of inquiry of primary importance—

1. Were the specimens obtained in situ in a geological formation?
2. What was the geological age of the formation?
3. Did the flints show indubitable proof of the handiwork of Man?
4. Could such a sequence of types of implements be established in this country as to enable geologists to use implements as zone-fossils in the deposits of the Human Period?

He then called upon each exhibitor to explain briefly the nature and object of his exhibit.

Mr. J. R. Moir exhibited specimens which included (1) implements from the base of the Suffolk Red Crag, comprising the well-known rostro-carinate type, borers, pointed forms, flakes, and scrapers; also some Cetacean bones which presented the appearance of having been fashioned by man; (2) flints flaked by the exhibitor, showing the various stages in the manufacture of a rostro-carinate implement; (3) four groups of implements from the Middle Glacial gravel underlying Boulder-clay; (4) a series of implements from the Boulder-clay; and (5) a series of implements of the Strépy type of Rutot from a Glacial gravel apparently later in age than the Boulder-clay.

Mr. F. N. Haward exhibited a series of bulbs of percussion and facetted flints, many with edges chipped on one or more sides, from Glacial gravels and the Cannon-shot Gravels of Norfolk. He pointed out that the large rounded flints from the Cannon-shot Gravels were a mass of cones of percussion, some exhibited being 1½ inches in diameter at the base, and of character similar to those produced artificially. From a Glacial gravel at Lenwade specimens were shown of tabular flints with chipped edges, and others which simulated closely the 'hollow scraper' and 'one-edge' work usually attributed to the hand of Man. From gravel at Tuddenham, full of split flints fresh from the Chalk, the edges of the flints exhibited were chipped almost entirely from one side: this chipping he attributed with confidence to natural agencies. For some years he had been working at certain types of chipped flints which some would consider artefacts, but of which he had grave doubts; and he had collected a large series from a pit at Eaton, near Norwich. This pit from its basement bed, which is 1 foot thick, yielded a remarkable series of flints with chipped secondary edges of various shapes. The basement bed consisted of three zones: The bottom zone was made up of Chalk in process of disintegration. The middle zone consisted entirely of much fractured chalk flints, many of which come away as a mass of splinters and contain bulbous flakes. The splitting of these flints was due to crushing in situ under great pressure, but the flakes show little or no secondary chipping. The top zone yielded all the chipped specimens which he exhibited, and he pointed out that they all came from one face of the pit, that they were collected in a horizontal distance of 12 feet, and were picked out by hand. The specimens are generally scratched all over, and many show remarkable selective work on one edge. A like series was also exhibited from a similar basement bed at Harford Bridges. They also occur at East Runton and in many other places where the basement bed is

exposed. The so-called 'implements' generally occur where the basement bed is most crowded with flints.

In the speaker's opinion these chipped flints were simply the result of crushing by natural forces that acted during the cutting away of the Chalk, either by ice or snow before the gravels were deposited, or by lateral movement in the gravels under great vertical pressure.

Whenever a moving stone impinged on the sharp edge of a stationary flint, chips would be flaked off the flint along the lines of least resistance; but when the sharp edge of the flint is turned away from the impinging force no chipping will ensue. As regards the direct proof that these chipped flints were Nature's work, it was next to impossible to reproduce the conditions under which the natural chipping took place, and to make observations in a gravel buried under hundreds of tons of soil, ice, and snow. The speaker had, however, been able to exhibit naturally chipped flints which owed their character to the foundering of a mass of gravel in a pipe, the gravel breaking through a layer of flints in the Chalk.

Mr. S. Hazzledine Warren, in exhibiting the results of certain experiments upon flint, said that he wished to make it clear that these experiments were not conducted from the point of view of proving what Nature could do by the attempted simulation of natural causes, but from the point of view of investigating the properties of flint. What he was endeavouring to elucidate by experiment was the manner in which flint chipped when subjected to forces of measured strength applied in different directions. Many methods were being used, one of which was that of movement under pressure of a sled which could be loaded at will with different weights. This process resulted in the reproduction of the Kentish form of eolith, a load of 250 lb. being sufficient for the production of most of even the larger forms. It was, however, insufficient for the reproduction of the big chipping often present upon the sub-Crag flints.

In considering subsoil pressures, in a soil of medium weight (a clay-with-flints) a stone having a superficial area equal to a rectangle of 8 by $6\frac{1}{4}$ inches was under a pressure of 250 lb. at slightly less than 6 feet below the surface; at a depth of 50 feet the same stone would be under about nine times that pressure, while beneath 500 feet of ice it would be under forty times that pressure. It was important to remember that striated surfaces were associated with both the Kentish 'eoliths' and the sub-Crag flints, and these pointed to the conclusion that strong movements under pressure had actually operated upon the flints in question.

Although the speaker did not wish to postulate too close an analogy between experimental and natural conditions, yet if, broadly speaking, the chipping properties of flint discovered by experimental investigation could be relied upon as also applying under natural conditions, then such chipping as was seen in the flints in dispute might theoretically be expected to occur.

A small series of chipped flints obtained from the base of the Tertiary beds at Harefield was also exhibited. In this section the bulbous chips could be found in the facets of the parent blocks from which they had been forced away by the operation of subsoil pressure.

Mr. A. S. Kennard exhibited, on behalf of Mr. B. Harrison, a series of eoliths from the Chalk Plateau of West Kent. This type of worked flint was first described by the late Sir Joseph Prestwich and had formed the subject of a considerable literature. It is obvious that the palæoliths cannot be the earliest efforts of man, and, although some of the stratigraphical evidence of the plateau is conflicting, yet, on the whole, it would appear that they are older than the Palæolithic gravels. This is clearly seen at Swanscombe, where the 'eoliths' are certainly derivatives. In South Africa a similar sequence can be shown, and this is of the utmost importance. It was quite impossible to say definitely where the work of Nature ended and that of Man began. It was purely a personal matter, but the speaker was confident that many of these rudely chipped flints were human artefacts. As a group they differed from the sub-Crag flints and many other so-called 'eoliths'.

Colonel A. W. Jamieson exhibited a series of specimens that he had collected in the south-east of Hampshire, and he wished to draw attention to this district, for he thought that it deserved more consideration than it had yet received. The area is bounded on the north and west by the Meon, on the east by the Sussex border, and on the south is the undercliff of the Isle of Wight. This country is strewn with worked flints of all ages, especially so from the Chalk summit to the sea.

Worked flints were furnished by a series of gravels on the marine plain, summarized on the geological map as Plateau Gravel. The sections are good and constantly varying on account of the rapid destruction of the coast.

The bottom layer of these gravels, which rests on denuded Bracklesham Beds, consists of Arctic drift full of igneous erratics and crowded with flints of café-au-lait and ochre colour, together with subangular masses cut about in a manner similar to those exhibited by Professor Sollas. So-called 'eolithic' forms are abundant. Upwards early Palæolithic forms follow with the conventional Drift types, several of which were shown. On the top is the Brick-earth or Loess, crowded with worked flints which have the appearance of being Aurignacian. They include steep-sided side-scrapers and segmental tools. In this deposit the speaker had discovered a human skeleton, minus the skull, the bones of which are now undergoing examination by Professor Keith. Above the marine plain a point of interest is the conspicuous hill of Portsdown, which has yielded a vast number of flints, worked on one side, shorn off flat on the other, and bearing conspicuous cones and bulbs of percussion.

The high Chalk of the interior is in places patched with Clay-with-Flints which has withstood destruction, and is rich in fabricated flints, which, in the speaker's opinion, were chiefly Mousterian.

Implements were also shown from Catherington, Hixton, Windmill Hill, and Blendworth, the last-named locality being rich in segmental tools and half-finished work showing huge cones of percussion. The speaker urged the view that the Clay-with-Flints was a formation coeval with the history of Man.

Professor Sollas exhibited a series of specimens to illustrate the production of 'rostro-carinate' forms of flint by natural agencies.

One from the top of the Chalk at Swanscombe showed jointing in situ, and some from the beach under the Chalk cliffs of Alum Bay the effects of wave-driven pebbles; but the great majority were obtained by Mr. E. Heron-Allen from the beach of Selsey Bill, and it was to these that attention was especially directed. If they were all of human workmanship—Sir E. Ray Lankester's contention—there would be no difficulty in accounting for the characters which they possess in common, notably their abundant and bold flaking; but then the fact that some examples were bounded on one side by planes of Pleistocene age and on the other by planes of recent origin would remain unexplained. If, on the other hand, only certain specimens were selected as artefact—Mr. J. R. Moir's interpretation—then it became difficult to explain the flaking which they all possess in common; and the fact will still remain that 'rostro-carinate' forms may be produced by flaking of widely separate ages. Some of the flints showed recent chipping under circumstances which suggest that this had been produced by the blows of pebbles driven inland from the sea: that is, in one direction. Attention was also called to 'rostro-carinate' forms projecting from the side of a large boulder of flint.

The Rev. H. H. Winwood exhibited specimens of quartzite and flint implements from the Broom, Farnham, and Knowle gravel beds. His object was to show the gradation from the well-worked implements of undoubted human origin to the fractured specimens from the Brinkworth plateau gravels 400 feet above O.D., the so-called 'eoliths', the origin of which is so much disputed. A porcellanous or more probably altered chert implement from Somaliland and a flint specimen from the cave shelter at Le Moustier showed how universally this type prevailed. Especial attention was called to a broken flint found by himself in the Knowle gravel-pit at Savernake, which had a remarkable glaze over the surface, not only of the fractured but also of the old surface, the cause of which yet awaited explanation.

Mr. H. N. Ridley exhibited a series of stone implements from the eastern coast of the Malay Peninsula, found in river-gravel and in one case on a bed of alluvial tin-ore. Nothing further is known of the race which made these tools, and it is certain that it is long extinct. He also showed some modern Papuan weapons of stone, in order to illustrate the methods of fastening the stones to the handles, and some sandstone tanged adzes with shell ornaments and spindle-whorls from the lake-dwellings of Kampong Thom in Cambodia, also of unknown date.

Mr. O. A. Shrubsole exhibited a few specimens from the Reading district in order to show difference of age and variety of use. The eoliths were from the gravel of the Easthampstead plateau (300 to 400 feet O.D.). The palæoliths included hollowed scrapers (highly developed from the eolithic type), gimlets or drills, knives (sometimes with a tang for insertion in a handle), saws, choppers, pickaxes, and polishers. One of the last-named still bears a finger-print of ancient man. Heavy two-handed choppers also occurred, identical in form with a specimen shown from the base of the Red Crag. Two at

least of the Crag specimens were good Palæolithic types. He showed in addition three specimens of bone (radius and rib of *Bos*) which had been cut very neatly by a flint instrument. Two flint implements were also exhibited which, by the difference of patina, indicated that they had been reworked at a much later date.

Mr. W. Dale exhibited a series of naturally formed or naturally fractured flints; these included an assortment of flakes caused by the bursting or expansion of the flint. One of these, on the base of an Echinoid, remains in situ, and can be taken out and replaced in the cavity. Some specimens illustrated the 'starch-fracture' arising from the partly crystalline nature of the flint and producing irregular prisms. From implementiferous gravels he exhibited a quantity of the fossil organisms known as *Coscinopora*. In the Chalk these are imperfectly pierced, but in the gravel the holes become enlarged, and Sir Charles Lyell and Mr. Worthington Smith thought that they might have been used as ornaments. The specimens shown were obtained from a gravel-digger, who was in the habit of placing them on strings. Flints which simulate Palæolithic implements in their form were also shown, and a collection of natural shapes somewhat resembling animal forms, one of them strikingly like a human head. The speaker would not have thought it worth while to show these last, but for the fact that the vagaries of the late Auberon Herbert had found another exponent, and the Journal of the British Archæological Association had this year published drawings of a number of these objects and advanced them to the dignity of artefacts.

Mr. N. F. Robarts wished to draw particular attention to some of the eoliths which he exhibited, found upon the plateau of the North Downs in Surrey, at 800 feet above O.D., near the crest of the escarpment. Of these some were rolled, and it was therefore evident that these must have been derived from the Chalk dome which formerly existed over the Weald.

Mr. G. W. Lamplugh showed a fragment of glaciated clay-stone of rectangular shape from the Boulder-clay of a Flintshire colliery shaft, as an example of the artificial aspect occasionally brought about by natural fracture. The shape of this example was remarkably close to that of a manufactured whetstone. The speaker observed that, where the cause of fracture was uncertain, it became of prime consequence to know the proportion that selected specimens bore to the total number examined: since, if the supply of naturally fractured stones be unlimited, exceptional types such as the specimen that he exhibited must occasionally be found.

Mr. W. H. Cook exhibited fifty examples of eoliths and thirty palæoliths collected from the northern flank of the Weald. As a result of his investigations the speaker questioned the pre-Palæolithic age of the eoliths of this area: for during the last six years he had found considerable numbers of palæoliths lying in conjunction with eoliths on the surface at levels ranging from 450 to 765 feet above O.D. The implements of both classes are in a precisely similar mineral condition, and the amount of abrasion is likewise common to both. A typical Kentish eolith is a deeply patinated nodule of flint with one or more of its edges chipped, such chipped edges being

in general of a lighter ochreous patination than the other parts of the nodule. It was noteworthy that some of the deeply patinated palæoliths had a subsequent or rechipped edge with exactly similar characteristics in regard to patina and angle of chipping as the eoliths with which they were associated. It had been said that palæoliths did not occur beneath the humus, but the speaker had had excavations made at levels of 450 and 520 feet above O.D. At the lower level he had found numerous eoliths and a rolled Palæolithic flake at a depth of 4 ft. 6 in.; at a further depth of 2 feet he found unrolled unochreous eoliths. At the higher level he had detected a much rolled Palæolithic implement in conjunction with numerous eoliths. He considered, therefore, that the contemporaneity of eoliths and palæoliths was beyond doubt.

Mere crudity of the fabrication of an implement could not be regarded as an indication of pre-Palæolithic antiquity: for, if that were allowed, many rudely fashioned implements, found associated with the higher forms in the drifts of our river-valleys and on the surface with polished tools, would have to be regarded as of greater antiquity than the finished examples, whereas there was good evidence to the contrary. This claim to a pre-Palæolithic antiquity for implements of crude workmanship could not be upheld when with them were found Palæolithic implements of Chellean and Acheulian types, in precisely the same mineral condition and showing a like amount of abrasion.

Mr. Reginald A. Smith referred to the type series of flints from the excavations carried out in 1912 on behalf of the Geological Survey and the British Museum. The official account was about to be published by the Society of Antiquaries (*Archæologia*, vol. lxiv), and dealt with the 100 ft. terrace gravels at Milton Street, Swanscombe, long known as a most prolific site. The 35 ft. section of Pleistocene deposits contained three bands of gravel, separated by two bands of loam. The lowest gravel, resting on Thanet Sand, contained a large number of struck flakes, unrolled and without secondary chipping, but no implements in the ordinary sense of the term, though some chipped cylindrical nodules might be regarded as of Strépy type. The Chellean types occurred abundantly in the middle gravel, especially in its lower section, the industry higher in the same bed showing an approach to Acheulian forms; but though the latter had been found from time to time in the pit and in the vicinity, no results were obtained during the excavations. Subsequently Mr. Dewey had acquired a series of unrolled Acheulian implements, mostly twisted ovates, from a bed corresponding to the Upper Gravel, in an adjoining pit. Hence the whole series, generally known as the Drift, seemed to be represented in the 100 ft. terrace-gravels, as was also the case in the Somme Valley. This did not preclude the possibility of Drift forms occurring in gravels at higher or lower horizons; and recent discoveries on the North Downs and other sites in the South-East of England suggested that some of the beds mapped as Plateau Gravel were laid down or re-arranged in the period named after St. Acheul.

A discussion on the above-mentioned exhibits then followed.

2. *December* 3, 1913.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

The following communications were read—

1. "A Contribution to our Knowledge of the Geology of the Kent Coal-field." By Dr. E. A. Newell Arber, M.A., F.L.S., F.G.S.

In this paper an attempt is made to give a general and connected account of the Carboniferous rocks of Kent, based on the evidence of some nineteen borings or sinkings. The Mesozoic cover of this wholly concealed coal-field is ignored. It is shown that the proved area is 200 square miles (128,000 acres), partly lying beneath land, and partly beneath the North Sea, the Straits of Dover, and the English Channel. The general strike is about 30° south of east and north of west, and the dip of the Transition Coal-measures is 2° to 3° in the two localities where reliable evidence is alone available on this point.

The area, as a whole, is a syncline, limited on the north and south by Armorican folds, of which the northern has been now fairly accurately located. There is evidence also of a fold on the east; and it is maintained that the Kent Coal-field is not continuous with that of the Pas de Calais. There are reasons for believing that the western boundary is a great fault.

The chief surface feature of the Coal-measures is that of an inclined plane, sloping rapidly but regularly westwards and south-westwards from an elevated region near Ripple and Deal in the east.

The Lower Carboniferous rocks exceed 450 feet in thickness, and were denuded before the Coal-measures were deposited.

The Coal-measures consist of the Transition Series (1,700 to 2,000 feet thick), and the Middle Coal-measures (2,000 feet). No Lower Coal-measures or Millstone Grit occur. The measures are grey throughout, and no red rocks, Espley rocks, *Spirorbis*-limestones, nor igneous rocks occur.

The coals are well distributed, and are often of considerable thickness, although there is a frequent tendency to splitting and inconstancy. Steam and household coals predominate, but gas coals also occur.

The most productive portions of the measures are the higher part of the Transition and the lower part of the Middle Coal-measures.

2. "On the Fossil Floras of the Kent Coal-field." By Dr. E. A. Newell Arber, M.A., F.L.S., F.G.S.

The floras of ten further borings in Kent are here recorded, and the number of species known from the Kent Coal-field is raised to 96, as compared with 10 known in 1892 and 26 in 1909. A number of the more interesting records are described and figured, some of them being new to Britain or not previously found on the horizons in question.

As regards the horizons present in Kent, the plant-remains indicate that, in the area so far proved, only Middle or Transition Coal-measures, or both, occur.

3. *December* 17, 1913.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

"Supplementary Note on the Discovery of a Palæolithic Human Skull and Mandible at Piltdown (Sussex)." By Charles Dawson, F.S.A., F.G.S., and Arthur Smith Woodward, LL.D., F.R.S., Sec.G.S.

The gravel at Piltdown (Sussex) below the surface-soil is divided into three distinct beds:—

The first, or uppermost, contains subangular flints and 'eoliths', and one palæolith was discovered there in situ.

The second is a very dark bed, composed of ironstone and subangular flints. All the fossils so far found in the pit have been discovered in or traced to this bed, with the exception of the remains of deer. A cast of a Chalk fossil, *Echinocorys vulgaris*, from the zone of *Micraster cor-testudinarium*, occurred as a pebble.

The third bed was only recognized this year, and consists of reconstructed material from the underlying Wealden rock (Hastings Series). It is only about 8 inches thick, and contains very big flints (8 to 15 inches long), which have been little rolled, and are not striated. They are saturated with iron, and have undergone considerable chemical change. They differ very markedly in appearance from the smaller flints in the upper strata. No implements, 'eoliths,' nor fossil bones have been met with in this bed.

The floor of the gravel, where the remains of *Eoanthropus* were discovered, has been carefully exposed, and many irregularities and depressions have been found to exist. In some of these depressions small patches of the dark overlying bed remained, and new specimens were recovered. The method adopted in excavation is described.

The finds made this year are few but important, and include the nasal bones and a canine tooth of *Eoanthropus*, also a fragment of a molar of *Stegodon* and another of *Rhinoceros*, an incisor and broken ramus of Beaver (*Castor fiber*), a worked flint from the dark bed, and a Palæolithic implement from the debris in the pit. It will be noted that the remains are those of a land fauna only. The further occurrence of bedded flint-bearing gravels in the vicinity of the pit is noted.

The authors' former conclusions, as to the Pliocene forms having been derived, are maintained.

A further study of the cranium of *Eoanthropus* shows that the occipital and right parietal bones need slight readjustment in the reconstruction, but the result does not alter essentially any of the conclusions already published. The nasal bones, now described, are typically human, but relatively small and broad, resembling those of some of the existing Melanesian and African races. The right lower canine tooth may be regarded as belonging to the imperfect mandibular ramus already described. It is relatively large and stout, and, like the molar teeth, it has been much worn by mastication. The worn surface on the inner aspect extends down to the gum, and proves that the upper and lower canines completely interlocked, as in the apes. In shape the canine resembles the milk-canine of man

and that of the apes more closely than it agrees with the permanent canine of any known ape. In accordance with a well-known palæontological law it therefore approaches the canine of the hypothetical Tertiary Anthropoids more nearly than any corresponding tooth hitherto found.

The rolled fragment of an upper molar of *Rhinoceros* is highly mineralized, and has the appearance of a derived fossil. It is specifically indeterminable, but seems to agree best with the teeth of *Rh. etruscus* or *Rh. mercki* (=*leptorhinus*, Owen).

II.—Mineralogical Society.

Anniversary Meeting, *November* 11.—Dr. A. E. H. Tutton, F.R.S., President, in the Chair.

A. Hutchinson and A. M. MacGregor: A Crystalline Basic Copper Phosphate from Rhodesia. The mineral occurs at the Bwana M'Kubwa copper-mines as a crust of minute, brilliant, peacock-blue, orthorhombic crystals, associated with malachite. Axial ratios $a:b:c = 0{\cdot}394:1:1{\cdot}01$; forms 110, 011; hardness 4–5; specific gravity 4·1. Chemical composition, determined by an analysis of a small quantity of carefully-selected material, approximates to the formula $2\,Cu_3(PO_4)_2,\ 7\,Cu(OH)$; no water is lost on heating to 190°. Although it has much the same composition as some minerals included in the pseudomalachite family, it differs widely in its physical characters from dihydrite, the only well-defined crystalline member of the group, and is probably a new species.—Dr. G. T. Prior: On the Meteoric Stone of Wittekrantz, South Africa. The stone, which fell on December 9, 1880, at the farm Wittekrantz, Beaufort West, Cape Colony, is slightly chondritic, and consists of the usual aggregate of olivine and bronzite, with particles of nickeliferous iron and troilite. In chemical and mineral composition it is very similar to the Baroti meteorite previously described.—Dr. G. T. Prior: On the remarkable similarity in chemical and mineral composition of Chondritic Meteoric Stones. The close similarity presented by most chondritic meteoric stones, although generally recognized, has to some extent been obscured by the unduly elaborate classifications which have been devised. A review of the quantitative mineral composition of forty-two chondritic stones, and a critical examination of the published analyses of others, lead to the conclusion that almost all those at present known are, except for some variation in the amount of nickeliferous iron, practically identical in chemical and mineral composition, the identity extending even to the chemical composition of the individual constituents. They approximate to the type with the following percentage mineral composition: nickel-iron (Fe : Ni = 10) 9, troilite 6, olivine (Mg : Fe = 3) 44, bronzite (Mg : Fe = 4) 30, felspar 10, chromite, etc., 1.—Arthur Russell: Notes on the Minerals occurring in the neighbourhood of Meldon, near Okehampton, Devonshire. The principal species are datolite, in crystals sometimes 2½ cm. in length, sea-green in colour and nearly transparent, polysynthetically developed, and showing a cleavage parallel to 001;

apophyllite in three types, square, tabular, and pyramidal; pyrrhotite in thin hexagonal plates; tourmaline in black, brown, green, blue, and pink crystals, sometimes zoned; garnet in colourless cubo-dodecahedra and trapezohedra, sometimes including wollastonite hairs; wollastonite abundantly in pure-white fibrous masses.—J. B. Scrivenor: On a Calcium-iron-garnet from China. It is interesting on account of its unusually easy solubility in hydrochloric acid without ignition.

III.—Zoological Society of London.

November 25, 1913.—Professor E. W. MacBride, M.A., D.Sc., F.R.S., Vice-President, in the Chair.

Mr. T. H. Withers, F.G.S., contributed a paper, communicated by Dr. W. T. Calman, F.Z.S., based upon a large series of Cirripede remains from the Cenomanian Chalk Marl in the neighbourhood of Cambridge. The greater number of the specimens are referred to two species of the family Pollicipedidæ, and add materially to our knowledge of the phylogeny of the pedunculated Cirripedes. Both forms are remarkable for their advanced form of scutum, in which the umbo is sub-central, and show that the transition of the scutal umbo from an apical to a sub-central position was acquired independently by unrelated forms in distinct lines of development.

OBITUARY.

SIR ROBERT STAWELL BALL, LL.D., F.R.S., F.R.A.S.

Born July 1, 1840. Died November 25, 1913.

Sir Robert Ball was born in Dublin and was the son of Dr. Robert Ball, an ardent naturalist and Director of the Museum in Trinity College. After graduating as University student in Mathematics in that college, Robert Ball (the younger) was appointed Astronomer to the 3rd Earl of Rosse at Parsonstown in King's County. He was elected a Fellow of the Royal Society in 1873, and eventually became Lowndean Professor of Astronomy and Geometry in the University of Cambridge and Director of the Cambridge Observatory. To geologists he was known chiefly as the author of a small volume on *The Cause of an Ice Age* (1891), a work reviewed by the Rev. Osmond Fisher (Geol. Mag., 1892, p. 231). He described it as containing "a very clear and agreeably written exposition of the commonly received Astronomical theory of Glacial periods", as adding "fresh force to Dr. Croll's hypothesis", but as "rather too triumphant" from the geologist's point of view. Since then Croll's hypothesis has been practically demolished by Mr. E. P. Culverwell in the pages of this Magazine (1895) and the Astronomical theory of the Ice Age has been abandoned. Sir Robert Ball was likewise author of a work entitled *The Earth's Beginning* (1901).

PROFESSOR IGINO COCCHI,

For. Corr. Geol. Soc. Lond.

BORN 1828. DIED 1913.

WE regret to record the death of the veteran Italian geologist, Professor Igino Cocchi, of the Museum of Natural History, Florence, Italy. Born at Terrarosia, in the Valdi Magra (province of Massa) in 1828, he at first devoted himself to literary studies, especially Latin literature, afterwards to chemistry, anatomy, and botany, and finally to mineralogy and geology, notably palæontology and stratigraphy. Having graduated at the University of Pisa, he completed his studies abroad, especially at Paris and London. Later on he gave to the town of Florence his collections, which formed the nucleus of an important palæontological collection.

Returned to Pisa, he was for some time assistant to MM. Savi and Meneghini; he collaborated with Cont. A. Spada and others in the reorganization of their collections; and finally was appointed Professor of Geology and Mineralogy at the R. Istituto di Studi Superiori in Florence.

He founded the Alpine Club of Florence, and in 1867, under the Minister of Agriculture (M. Cordova and afterwards M. Broglio), established the Reale Comitato Geologico.[1] He was not a prolific writer; only a dozen papers stand to his credit in the Royal Society Catalogue, and some twenty or so separate memoirs.

DR. ALFRED RUSSEL WALLACE,

O.M., LL.D., D.C.L., F.R.S., ETC.

BORN JANUARY 8, 1823. DIED NOVEMBER 7, 1913.

THE closing year (1913) has borne away another of the great naturalists of the nineteenth century, whose researches and writings have so profoundly influenced biological science, and opened up for us entirely new conceptions of life both past and present.

Alfred Russel Wallace was born at Usk, Monmouthshire, on January 8, 1823; his family was not Welsh but Scottish in origin. His father, a man of literary tastes, was a briefless barrister with a family of nine children, of whom Alfred was the youngest but one. The future naturalist left school at 14, and from that time set himself to read *Mungo Park*, *Robinson Crusoe*, *Gulliver's Travels*, and later Lyell's *Geology*, Darwin's *Journal of a Naturalist*, Humboldt's *Travels*, *The Vestiges of Creation*, etc. His parents intended he should become a land surveyor and architect, but Nature designed him for a traveller and naturalist, and Dame Nature as usual prevailed. He practised surveying for some time in the Midlands and in Wales. Later on he was drawing master at the Collegiate School, Leicester. Here he became acquainted with Henry Walter Bates, and this proved the turning-point in his career. Bates, like Wallace, was born to be a naturalist, and the two decided to go in company to the Tropics to study animal life and make collections. They sailed from London in 1848. Wallace spent the next four and a half years collecting birds in South America. Returning home in

[1] From Gubernati's *Dict. Internat. Ecrivans du Jour.*